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NEW ZEALAND
DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

BULLETIN 114

Diseases and Pests of Peas and Beans in New Zealand and their Control

By

R. M. BRIEN, E. E. CHAMBERLAIN, W. COTTIER, I. A. M. CRUICKSHANK,
D. W. DYE, H. JACKS, AND W. D. REID

Plant Diseases Division
Department of Scientific and Industrial Research
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Introduction

THE main leguminous crops grown in New Zealand for food consumption are peas, dwarf and runner beans, and broad beans. In the following bulletin, diseases and insect pests commonly occurring on these host plants in the Dominion are described, and measures for their control recommended.

The bulletin comprises sections dealing with fungous, bacterial, virus, and physiological diseases, insect pests, and the application of plant therapeutants.

The writers wish to acknowledge the assistance given by many officers of the Extension Division and Horticulture Division, Department of Agriculture, who forwarded specimens from different districts. We also wish to thank those growers and seed merchants throughout the Dominion who co-operated to make disease surveys possible. We are indebted to the technical staff of the Plant Diseases Division, in particular Messrs A. Hastings, E. M. Hay, R. Nodder, C. H. Procter, and A. J. Webb, and also I. K. Barron, Crop Research Division, for technical assistance in carrying out investigations on diseases and pests of peas, beans, and broad beans.

Our thanks are due also to Miss M. J. Dahlberg and Messrs H. Drake, W. E. Barnard, L. H. Wright, S. A. Rumsey, R. I. Hughes, J. W. Endt, H. E. Powell, D. Reed, B. B. Given, and H. Tooley for most of the photographs used as illustrations.

Garden and Field Peas

In the *New Zealand Official Year-Book*, 1950, peas, including both garden peas (*Pisum sativum*) and field peas (*Pisum sativum* var. *arvense*), are classified as one of the principal field crops in New Zealand. In 1948-49 an area totalling 49,152 acres was sown in peas, with a total yield of 1,195,196 bushels—an average of 24.32 bushels per acre. A total of 848,307 bushels, valued at £1,004,540, was exported, mainly to the United Kingdom and Australia.

In addition to their production for export and internal seed trade, garden peas are grown extensively as a field crop for canning, and in market and home gardens as a green vegetable, while field peas are



Photo H. Drake

Fig. 1.—Collar rot: Pea leaves infected with *Ascochyta pisi*



Photo H. Drake

Fig. 2.—Collar rot: Pea pods infected with *A. pisi*

grown widely for stock food and production of split peas. The main garden varieties grown in the Dominion are William Massey, Greenfeast, and Onward, and the main field varieties are Partridge and Blue Prussian.

Peas, wherever grown, are subject to a number of diseases which, because of their serious effect on yield and market value, are a major factor in crop production. In order to assess the incidence and

importance of diseases in pea crops, three surveys were made during the period 1948-50 covering the following districts: Auckland, Pukekohe, Blenheim, and North and Mid-Canterbury. Crop inspections were made during November and December of each year, i.e., just after flowering of plants. From results of these surveys it was found that the disease picture was fairly constant from year to year, and that diseases in this country may be roughly classified into major and minor diseases as follows:

Major Diseases: Collar rot and pea wilt.

Minor Diseases: Fusarium foot-rot, septoria blotch, downy mildew, powdery mildew, grey mould, sclerotinia disease, damping off, bacterial blight, pea mosaic, tomato spotted-wilt, pea streak.

FUNGOUS DISEASES

COLLAR ROT

Three closely related fungi, *Ascochyta pisi* Lib., *Ascochyta pinodella* Jones, and *Mycosphaerella pinodes* (Berk. and Blox.) Stone, are responsible for the various symptoms of the disease known as the collar-rot complex. *A. pisi* attacks pods, seeds, and leaves, and sometimes stems, while *A. pinodella* and *M. pinodes* produce lesions on pods, seeds, leaves, stems, and roots. *M. pinodes* occurs more commonly than the other two fungi.

Collar rot is widespread in all districts, but causes most damage in Auckland and Blenheim.

The effects of collar rot may be either direct or indirect. A high percentage of infected seed in a line is often responsible for poor stands and severe collar rot which reduces vigour of plants in the crop. In market gardens and canning crops, disfigurement of pods results in reduction of their commercial value. Indirectly collar rot lowers yield per acre.

SYMPTOMS

A. pisi causes sunken, light-tan to brown spots, $\frac{1}{4}$ in. to $\frac{1}{2}$ in. in diameter, usually surrounded by a prominent margin. On leaves and pods, spots are circular and often show light and dark concentric zones (Figs. 1 and 2), while on stems and leaf stalks they are usually elongated (Fig. 3). Dark-brown dots, which are the fruiting bodies of the fungus, are usually visible near the centre of the spots.

On leaves, *M. pinodes* and *A. pinodella* produce purple to dark-blue, irregular, angular spots approximately $\frac{1}{4}$ in. in diameter, with indefinite margins (Fig. 4). Under moist conditions spots may enlarge, becoming circular and zoned. However, they cannot be confused with those of *A. pisi* as they are always much darker in colour. On stems, blue-black



Photo H. Drake
Fig. 3. Collar rot: Pea stem infected with *A. pisi*

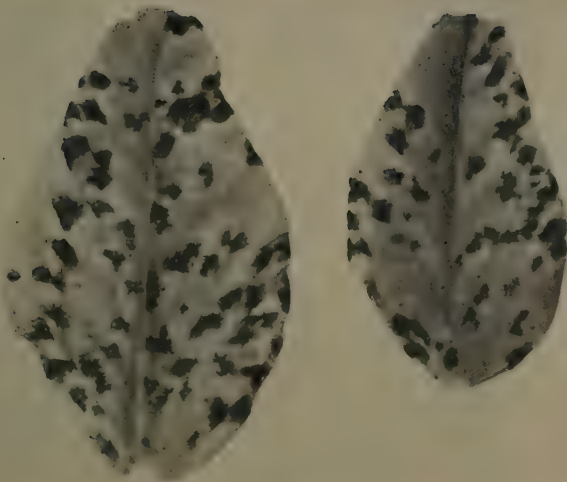


Photo S. Rumsey

Fig. 4.—Collar rot: *Mycosphaarella pinodes* on pea leaves

to purple streaks are formed, and these often completely encircle the base and root for several inches (Fig. 5). This is the typical collar-rot symptom from which the disease derives its name.

HOST RANGE

In other countries collar rot occurs on a number of host plants, but in New Zealand it has been recorded only on peas and blue lupins. In general, it is not a serious disease on the latter host.

FACTORS FAVOURING INFECTION AND SPREAD

The organisms causing collar rot are commonly carried over from one season to the next within the tissues of the seed coat, and also as spores on the surface of seed. *A. pinodella* and *M. pinodes* are also carried in the soil, where they may survive for



Photo S. Rumsey

Fig. 5. Collar rot: Pea plant infected with *Mycosphaarella pinodes* on leaves and at base of stem

two to three years in the absence of a suitable host plant. Another source of infection is diseased pea vines and pea stubble, on which spores may

be formed. Spores are liberated in the spring and carried considerable distances by air currents. Secondary infection occurs during the growing season by rain splashing spores from infected plants to others nearby.

The severity of collar rot varies considerably with seasonal conditions. In general, a wet season, moderate temperatures, and high relative humidities during harvest are most conducive to severe development and widespread dispersal of collar-rot fungi. Heavy, poorly drained soils favour severe foot-rot infection. In areas where peas are grown in close rotation, the incidence of this disease is high and severe damage results, but where long rotations are practised, or peas are sown out of old pasture, the incidence of collar-rot is negligible.



Photo S. Rumsey

Fig. 6.—Pea wilt: Comparison of infected plants; left, five weeks after sowing in infected soil, and right, healthy plants same age in clean soil

TABLE 1. MATERIALS AND CONCENTRATION RECOMMENDED FOR SEED TREATMENT

Chemical	Trade Names	Percentage Active Ingredients	Pea		French Bean		Diseases and Pests Controlled
			Ounces Per 100 lb.	Level Teaspoons Per Pound	Ounces Per 100 lb.	Level Teaspoons Per Pound	
DDT (dichloro diphenyl tri-chloroethane) para isomer	D-Dust No. 1 D-Dust No. 2 Puff	1	...	...	4	$\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$	Bean weevil.
		2	...	...	2		
		2	...	...	3		
Gamma BHC (lindane) (99/100% gamma isomer of benzene hexachloride)	Nexa Dust Lindane Dust	1	...	...	4	$\frac{1}{2}$ $\frac{1}{2}$	Bean weevil.
		1	...	...	4		
Ferbam (ferric dimethyl dithiocarbamate)	Fernspray*	70	8	$\frac{1}{2}$	8	$\frac{1}{2}$	Seed decay and damping off.
Thiram (tetramethyl thiuram disulphide)	Tetram* Fernasan* Premasan* Thiodust*	98	2	$\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$	2	$\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$	Seed decay and damping off.
		50	4		4		
		50	4		4		
		75	2		2		
Dichlone (dichloro naphtho-quinone)	Phygon Phygon XL	98	2	$\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$	2	$\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$	Seed decay and damping off.
		50	3		3		
Chloranil (tetrachloro para benzoquinone)	Spergon Tetroc	98	4	$\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$	4	$\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$	Seed decay and damping off.
		98	4		4		

*To improve passage through drills it is advisable to add 2 oz. of graphite to each 100 lb. of seed treated with this material.

RESISTANT VARIETIES

No resistant varieties are known. It has been claimed, however, that early maturing varieties suffer less than late maturing ones. This is probably the result of avoidance rather than resistance to collar rot, but it may be an important factor in crop management for field control of the disease.

CONTROL MEASURES

All crop refuse, i.e., pea stubble and vines, should be either ploughed in deeply or gathered up and burnt after harvest.

Seed for resowing should be saved from clean crops wherever possible, preferably from those sown out of pasture and in dry districts.

Seed should be dusted before sowing with a fungicidal seed dressing such as Spergon, Tetroc, thiram, or Phygon XL (see page 13).

A crop rotation of at least four years between pea crops should be practised wherever possible. Where more than one crop of peas has been grown in succession, longer periods may be necessary.

PEA WILT

Pea wilt is caused by the fungus *Fusarium orthoceras* Appel. & Wollenw. var. *pisi* Linford. It was first recorded in New Zealand in 1948, when it was observed in Canterbury, Marlborough, and Auckland. The most serious losses occurred in pea crops in the Marshlands-Belfast-Harewood and Tai Tapu-Leeston-Southbridge areas. In cases of severe infection, losses in yield may be from 50% to 100%.

SYMPTOMS

On diseased plants the first sign of infection is a downward curling of leaves, which gives them a rolled appearance (Fig. 6). Stems and leaves are at first covered with a dull bloom. Later they lose colour and become rigid, and joints of leaflets become brittle. Stems and roots commonly have an orange or brick-red internal discoloration (Fig. 7), although this symptom does not always occur. No external symptoms occur either on stems or roots,



Photo S. Rumsey

Fig. 7.—Pea wilt: Showing left, vascular discoloration and wilted leaves on infected plant, right, healthy plant same age

except that the lower portions of stems may be slightly swollen. Infected plants turn pale, yellowish green, and usually die in approximately seven to ten days.

Pea wilt is visible at any stage of growth up to flowering as circular patches of brown, dead pea vines scattered through the crop (Fig. 8). These patches vary in diameter from a few feet to several yards according to the extent of soil infection.

HOST RANGE

In New Zealand, pea wilt has been observed only on peas, but in other countries it sometimes infects broad beans and other members of this genus.

FACTORS FAVOURING INFECTION AND SPREAD

Moderate soil temperatures of 64° F to 72° F are favourable for wilt development. Wet soil conditions favour early development of symptoms, while drier conditions lead to rapid death of infected plants. The disease is favoured by light-textured soils and persists most readily in soils rich in organic matter. The disease may be carried on the seed, although this method of spread is rare. However, it may be spread by infected soil adhering to seed, and also by animals, man, flood waters, etc. Once introduced into a field, the causal organism can live indefinitely in the soil, survival after fifteen to seventeen years under pasture having been recorded.

RESISTANT AND SUSCEPTIBLE VARIETIES

During recent years trials have been carried out with local and imported pea varieties to determine their resistance to pea wilt. Resistant and susceptible varieties are listed below.



Photo I. A. M. Cruickshank

Fig. 8.—Pea wilt: Showing wilt-infected patch in crop of Onward peas

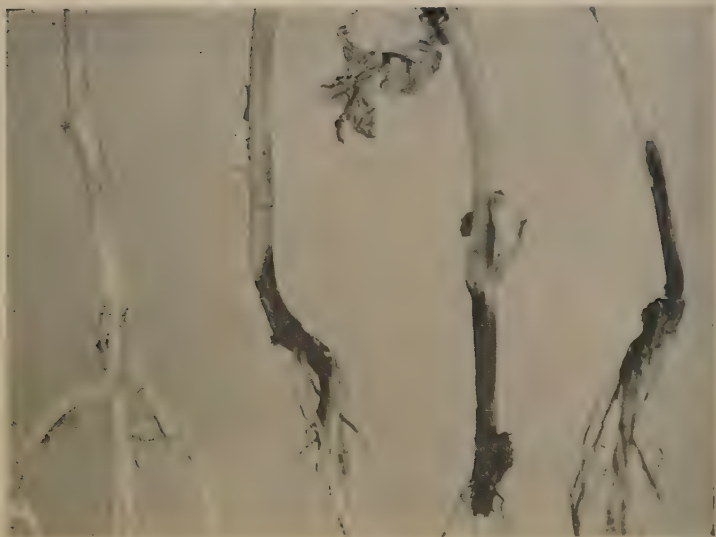


Photo S. Rumsey

Fig. 9.—Fusarium foot-rot: Infected pea plants showing rotting at base of stems and on roots. Healthy plant on left

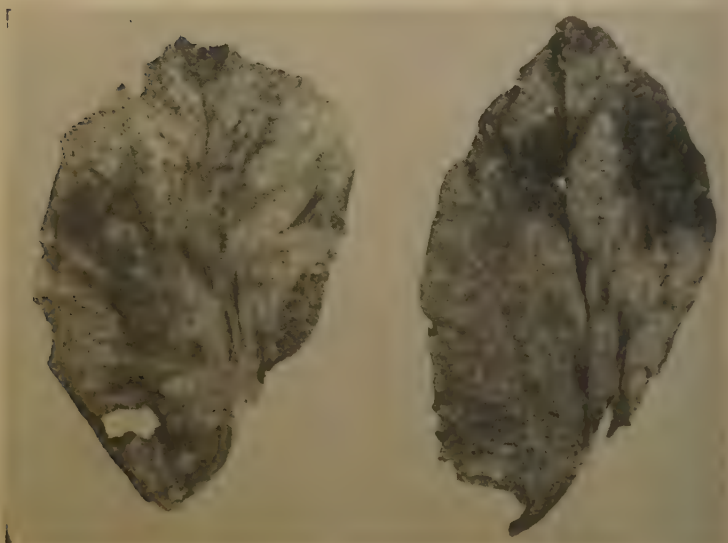


Photo S. Rumsey

Fig. 10.—Septoria blotch: Infected pea leaves showing irregular blotches and fruiting bodies

Garden Varieties

Resistant.—Alderman, Bliss Everbearing, Climax, Director, English Wonder, Epicure, Giant Alderman, Giant Stride, Glacier, Hurricane, Kelvedon Standby, Kelvedon Triumph, Laxton's Progress, Lord Chancellor, Major, Morse's Market, Multipod, Progress, Quartermaster, Queen, Stratagem, Triumph, Yorkshire Hero.

Susceptible.—Autocrat, Blue Bantam, Cambridge Multipod, Charles I, Churchill, Confidence, Coronation, Duplex, Exquisite, First and Best, Foremost, Gladiator, Greenfeast, Greencrop, Hursthouse, Kelvedon Monarch, Kelvedon Paragon, Laxton's Superb, Little Gem, Little Marvel, Meteor, Miracle, Onward, Phenomenon, Pilot, Pioneer, President Wilson, Radium, Spitfire, Superb, Thomas Laxton, Veitche's Perfection, V.C., William Massey, Wando, Witham Wonder.

Canning Varieties

Resistant.—Canner's King, Canner's Perfection, Commando 2685, Deep Green Perfection, Delwiche Commando, Delwiche 21, Early Badger, Horal, Merit, Penin, Perfected Whales, Perfection, Wisconsin Early Sweet, Wisconsin Perfection.

Susceptible.—Alaska, Canner's Queen, Early Perfection.

Field Varieties

Resistant.—Blue Prussian, Gruno, Hala, Harrison's Glory, Helios, Mammoth White, Marathon, Vinco, White Canada, Zelka I, Zelka II.

Susceptible.—Austrian Winter, Conservo, Mammoth Blue, Mansholt, Parel, Partridge, Rondo I, Rondo II, Unica, Victoria, White Prolific.

CONTROL

Control measures recommended for pea wilt are essentially the same as for collar rot. Destroy all crop refuse, do not use seed from diseased crops, dust seed with a fungicidal seed dressing (see page 13), and do not grow peas more than once in four or five years.

In addition, land known to be infected should be sown only with resistant varieties.

FUSARIUM FOOT-ROT

Fusarium foot-rot, caused by the fungus *Fusarium solani* Mart. var. *martii* Appel & Wollenw. f. 2 Snyder, has been observed affecting pea crops in Canterbury, Marlborough, Hawke's Bay, and Auckland. Recent surveys in these districts have shown that this disease occurs only in odd crops and that it is of minor importance.

SYMPTOMS

This fungus causes seed decay, seedling rot, and foot rot. Symptoms on maturing plants are dark, reddish-brown or chocolate-coloured lesions (Fig. 9) accompanied by internal rotting at base of stems. Lesions vary in length from 1 in. to 3 in., and at their upper limits are wedge shaped. At their base they may completely girdle the stem and extensively damage the main root system. Internal rotting may be

accompanied by a dark-red discoloration of the water-conducting tissues in centre of stems. Wilting and death of plants result when rot is extensive.

HOST RANGE

The disease occurs on peas and sweet peas, but is not important on the latter.

FACTORS FAVOURING INFECTION AND SPREAD

Foot rot is favoured by high soil temperatures, 78° F to 82° F, alkaline soils, and light-textured soils. There is no evidence that the fungus is carried within the seed, but it may be carried in soil mixed with seed. Farm implements, animals, man, flood waters, etc., distribute infected soil. Once infected, soil remains so indefinitely, and infection is gradually spread throughout a field. Rate of spread of foot rot is reduced when proper rotations are practised.

VARIETAL RESISTANCE

Of eighty varieties of peas tested, none showed resistance to the disease.

CONTROL

As no varieties are resistant to foot rot, and seed dusts have proved ineffective, the only control measures that can be recommended are as follows: burn all diseased crop refuse and leave an interval of at least five years between pea crops.

SEPTORIA BLOTCH

Septoria blotch, caused by the fungus *Septoria pisi* Westend., is a disease of minor importance in New Zealand. It has been observed in crops of field and garden peas in North Canterbury and Blenheim, and on garden peas in Wanganui and Auckland, but severe infection is rare. The disease was first recorded in New Zealand in 1949.

SYMPTOMS

Symptoms appear first on lower leaves as small, yellowish areas, which later develop into light-brown, necrotic blotches. The latter are irregular in shape, elongated, and limited to some extent by the leaf veins (Fig. 10). Minute light-brown dots (the fruiting bodies of the fungus), which darken with age, develop on the surface of diseased areas. As plants mature, infection may spread over leaves, leaf stalks, stems, and pods. Severe infection on young plants results in shrivelling of leaves, shrinking of stems, and finally wilting and death. On mature plants, symptoms are similar, but death rarely results as a direct effect of infection.

FACTORS FAVOURING INFECTION AND SPREAD

Temperatures of 68° F to 72° F and high relative humidities are most favourable for infection and extensive spread of septoria blotch. The disease is spread primarily by spores produced on infected pea stubble

or refuse remaining from a previous crop. Secondary spread of infection occurs during the growing season by rain splashing spores from plant to plant. The disease is not seed carried.

VARIETAL RESISTANCE

No variety of peas shows any appreciable resistance to the disease.

CONTROL MEASURES

All crop refuse should be either ploughed in deeply or burnt after harvest. To protect young seedlings, seed should be dusted with a fungicidal seed dressing before sowing (see page 13).

There should be an interval of two or three years between pea crops where possible.

DOWNY MILDEW

Downy mildew of peas is caused by the fungus *Peronospora pisi* (de Bary) Syd. It was first recorded in New Zealand in 1906, and has been found in all pea-growing areas on both field and garden peas. Although not of major economic importance, it is troublesome on early garden-pea crops, particularly in the Auckland district.

SYMPTOMS

The first symptoms of downy mildew are small yellowish spots on upper surfaces of leaves. As these areas enlarge, greyish-brown, cottony patches appear on corresponding undersurfaces (Fig. 11). If severely infected, leaves shrivel, turn brown, and die. On pods the disease shows as yellowish, slightly raised, irregular blotches. Infection on young stems and pods causes distortion, and checks growth.

FACTORS FAVOURING INFECTION AND SPREAD

Temperatures between 50° F and 70° F and high relative humidities are most favourable for infection. Downy mildew is checked by high temperatures (80° F and above) and dry weather. The disease is carried over in the soil on decaying vines and leaves, or may be introduced into new areas by infected seed. Secondary infection occurs from spores produced from plants during the growing season. These are carried by air currents and rain to other plants in the vicinity.



Photo M. J. Dahlberg

Fig. 11.—Downy mildew: Showing cottony areas of the fungus on underside of leaves and on tendrils



Photo S. Rumsey

Fig. 12.—Powdery mildew: Infected pea leaves showing light-coloured powdery areas

CONTROL MEASURES

Crop refuse should be either ploughed in deeply or burnt after harvest. Seed should be dusted with a fungicidal dust before sowing (see page 13).

Crop rotation with two or three years between pea crops should be practised where possible.

In market and home gardens the disease can be checked by spraying with bordeaux mixture or copper oxychloride plus wetting agent (see page 22). Two or three applications should be made at intervals of ten to fourteen days, commencing when seedlings first appear above ground.

POWDERY MILDEW

Powdery mildew, caused by the fungus *Erysiphe polygoni* DC., is a disease of minor importance in New Zealand. Results of surveys indicated that, although it was observed in a few crops in all districts, there was no evidence of widespread infection causing economic loss.

SYMPTOMS

The fungus forms a light-grey powdery coating on upper and lower surfaces of leaves and on stems and pods. This coating consists of a surface growth of the fungus and spores, which are produced in profusion, thus giving a powdery appearance (Fig. 12). In cases of severe infection, plants become distorted and dwarfed. Powdery mildew is mainly superficial, but in places penetrates the tissues, causing discoloration and death of small areas under the powdery coating. Late in the season minute black bodies may develop in the powdery layer; these are the overwintering phase of the fungus.

HOST RANGE

The disease is common on a wide range of wild and cultivated plants. In New Zealand it occurs on peas, sweet peas, swedes, turnips, rape, delphiniums, wineberry, and anemones.

FACTORS FAVOURING INFECTION AND SPREAD

Primary infection occurs either from conidia that have survived the winter, or from ascospores produced in the spring on infected pea stubble or refuse from previous crop. These are carried considerable distances by air currents. Secondary infection and spread of the disease to neighbouring plants occurs from abundant conidia produced on affected parts. These are carried by wind and rain splashing. Infection is favoured by dry conditions and temperatures of approximately 68° F. The disease may be expected to be more severe in a dry season.

CONTROL MEASURES

Crop rotation and burning of diseased pea refuse after harvesting are recommended. In market and home gardens, dusting with sulphur or spraying with lime sulphur 1-150 plus colloidal sulphur 2 lb. in 100 gal. at intervals of ten to fourteen days gives satisfactory control (see page 23).

DAMPING OFF

Damping off is caused by various soil fungi, mainly species of *Pythium*. There are two distinct types of injury: (a) pre-emergence damping off, where complete rotting of seeds or seedlings occurs before they emerge from the soil; and (b) post-emergence damping off, where seedlings are attacked after emerging and then wilt and die. Infected plants are darker green than normal and stems near ground level become constricted and watersoaked, and later collapse. In some cases brown lesions are also found on roots. Seedlings surviving the attack grow slowly and usually produce a poor crop.

For control of damping off the most economical method is to dust seed prior to sowing with thiram, Spergon, Phygon XL, or Tetroc (see page 13).

GREY MOULD

Grey-mould rot (*Botrytis cinerea* Pers.), which has been more fully described under bean diseases (see page 39), sometimes occurs on pea pods during periods of wet weather and high humidity, both in the field and in transit. This disease is of minor economic importance in New Zealand. It is usually found on pods near ground level or in contact with the soil.

SYMPTOMS

Grey mould appears first as watersoaked, greyish-green spots $\frac{1}{4}$ in. to $\frac{1}{2}$ in. in diameter. As spots enlarge,

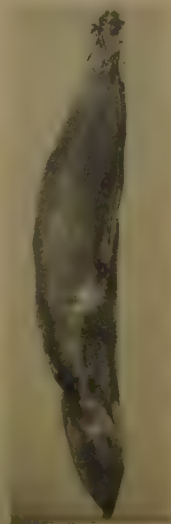


Photo S. Rumsey

Fig. 13. Grey mould: Showing infection on pea pod

TABLE 2. MATERIALS USED FOR PROTECTION OF PEA AND BEAN CROPS FROM DISEASES AND PESTS

Chemical	Trade Names	Percentage Active Ingredients	Quantities for 4 Gallons	Diseases and Pests Controlled	Treatment	Remarks
FUNGICIDES						
Bordeaux mixture (3-4-50, copper sulphate, hydrated lime, water)				(Pea downy mildew Bean anthracnose Bean halo blight Broad-bean leaf spot)	Apply soon after plants are established, and repeat at intervals of ten to fourteen days	Prepared by first dissolving the required amount of copper sulphate in hot water and mixing the required amount of hydrated lime to a paste. The hydrated lime is first added to the bulk of water, the solution of copper sulphate being poured in next. The mixture should be thoroughly agitated before use. Only fresh preparations should be used.
Copper sulphate Hydrated lime	Tr. Papapa Limbox Dysath Hindlym	98 95 95 95	6 lb. 8 lb. 8 lb. 8 lb.	4 oz. 5 oz. 5 oz. 5 oz.		
Copper oxychloride	Cop ox Cuprox Funguran Coxsan Oxi cop	50 50 50 50 50	5 lb. 5 lb. 5 lb. 5 lb. 5 lb.	3 1/2 oz. 3 1/2 oz. 3 1/2 oz. 3 1/2 oz. 3 1/2 oz.	Apply soon after plants are established and repeat at intervals of ten to fourteen days	Prepare a thin paste before adding to water.
Cuprous oxide	Cupromox Perimox	50 50	5 lb. 5 lb.	3 1/2 oz. 3 1/2 oz.	Apply soon after plants are established and repeat at intervals of ten to fourteen days	Prepare a thin paste before adding to water.

Poly sulphide sulphurs (lime sulphur)	Lawry's Te Papapa	15	$\frac{1}{2}$ gal.	5 fl. oz.	Pea powdery mildew	Apply soon after plants are estab- lished and repeat at intervals of ten to fourteen days	Lime sulphur and colloidal sulphur are used to- gether, the combination being more effective than separate compo- nents and safer to apply.
Colloidal sulphur	Colsul 25 Colsul 40 Sulphaloid	15 25 40 40	$\frac{1}{2}$ gal. 4 lb. 2 lb. 2 lb.	5 fl. oz. 2 $\frac{1}{2}$ oz. 1 $\frac{1}{2}$ oz. 1 $\frac{1}{2}$ oz.	Broad-bean rust		
Thiram (tetramethyl thiuram disulphide)	Thiospray Fertide Tetram W.	50 50 50	3 lb. 3 lb. 3 lb.	2 oz. 2 oz. 2 oz.	Bean grey mould Broad bean chocolate-spot	Apply when disease appears Apply soon after plants are estab- lished and repeat at intervals of ten to fourteen days	Mix into a thin paste before adding to water.

INSECTICIDES

DDT (dichloro di- phenyl trichloro- ethane) para para isomer	D-Dust No. 1 D-Dust No. 2 Puff Dust Timort (emulsion) Atapest (paste) DeDeTane (paste) D-Spray 50 (wetable) powder Pespruf 50 (wetable) powder	1 2 2 20 33 $\frac{1}{2}$ 40 50 50	$\frac{1}{2}$ pt. 1 lb. 1 lb. $\frac{3}{4}$ lb. $\frac{3}{4}$ lb.	$\frac{3}{4}$ fl. oz. $\frac{3}{4}$ oz. $\frac{3}{4}$ oz. $\frac{1}{2}$ oz. $\frac{1}{2}$ oz.	Slaters Looper caterpillar and red-legged earth mite	Apply to places fre- quented by these insects Apply at intervals of ten to fourteen days	Do not apply when pods are present on plants, to avoid toxic residue.
Gamma BHC (ben- zene hexachloride) or lindane	Lethalin Nexa	20 16	$\frac{3}{4}$ pt. 1 pt.	$\frac{3}{4}$ fl. oz. $\frac{3}{4}$ fl. oz.	Root aphid	Soak ground round roots	Preferably as eradicant treatment. Do not grow carrots or potatoes on this area for at least one season.

TABLE 2—*continued*

Chemical	Trade Names	Percentage Active Ingredients	Quantities for 100 Gallons	Diseases and Pests Controlled	Treatment	Remarks
INSECTICIDES—<i>continued</i>						
Nicotine sulphate	Black Leaf 40	40	1 pt.	Green aphid	Apply when infestation appears, and repeat ten days later Soak soil round seedlings	*For precautions, see footnote. The spray mixture should be alkaline to bring about liberation of nicotine fumes. For this purpose use soft soap or hydrated lime at 3 lb. to 100 gallons. When added to bordeaux mixture this is unnecessary.
	Black Spot	40	1 pt.	Bean aphid		
	Britnico	40	1 pt.	White fly		
	P.B.I. 40	40	1 pt.	Soil Collembola		
	Nicoforty	40	1 pt.			
TEPP (tetraethyl pyrophosphate)	Hexone Murphy Tepp	15 20	$\frac{1}{2}$ 1 pt.	Green vegetable-bug	Apply when infestation appears, and repeat ten days later	Use diluted spray within one hour of preparation. *For precautions, see footnote. No toxic residue on sprayed produce twenty-four hours after application
			$\frac{1}{2}$ 1 fl. oz.	Green aphid		
		40	$\frac{1}{2}$ 1 pt.	Bean aphid		
			$\frac{1}{2}$ 1 fl. oz.	White fly Thrips Red spider-mite Red-legged earth mite		

*When using TEPP or nicotine sulphate, observe the following precautions:

Avoid contact with the skin, especially when handling concentrates.

Wear rubber gloves and eye-shields.

Wash with soap and water after spraying.

Change contaminated clothing.

Avoid inhalation of mist.

Wear a respirator when working in a confined space.

Avoid contamination of food and eating or smoking in the spraying area.

Keep out of reach of children.

Dispose of empty containers.

TABLE 3. INSECT BAITS

Materials	Pests Controlled	Treatments	Remarks
Paris green $\frac{1}{4}$ lb., dried blood 14 lb.	Slaters	Broadcast over the soil at the rate of 1 oz. per square yard.	Mix poison and dried blood thoroughly.
Metaldehyde $\frac{1}{4}$ lb., bran 14 lb.	Slugs and snails	Place in small heaps spaced according to the damage occurring.	"Meta" should be in powder form to facilitate mixing with bran.

a fine white mould appears on the surface and, later, as spore clusters develop, the mould becomes greyish-brown and granular in appearance (Fig. 13). Pods showing the above symptoms should be discarded before peas are packed for market.

SCLEROTINIA DISEASE

Sclerotinia disease (*Sclerotinia sclerotiorum* (Lib.) de Bary) is occasionally found, causing a basal rot on stems and leaves of pea plants in the field and a watery soft-rot of pods. This disease is fully discussed in the section dealing with bean diseases (see page 37).

BACTERIAL DISEASES

BACTERIAL BLIGHT

Bacterial blight of peas, caused by *Pseudomonas pisi* Sackett, has been present in New Zealand for a number of years. It has been found in isolated crops in Auckland, Nelson, Blenheim, and Canterbury, but is of minor importance in this country. Early infection may cause death of seedlings, while infection on older plants causes reduction in yield and affects the market value of pods because of severe spotting.

SYMPTOMS

The disease usually becomes apparent early in the season on lower parts of plants. Lesions on leaves appear as watersoaked, green or greenish-brown angular spots which enlarge under humid conditions and finally become papery (Fig. 14). On stems, dark-green to greenish-



Photo S. Rumsey

Fig. 14.—Bacterial blight: Showing lesions on garden-pea leaflets



Photo M. J. Dahlberg

Fig. 15.—Bacterial blight: Showing infection on leaves, stem, and pod of garden pea

brown irregular areas are formed, which later become dark brown and shrivelled. Infection on pods appears first as small, dark-green, water-soaked spots, which become dark-brown to black, slightly sunken, with grey or greyish-brown centres (Fig. 15). During humid weather the seed in diseased pods becomes covered with a bacterial slime which either dries on the seed, or invades the seed coat, causing discoloured areas. Infected seeds give rise to diseased seedlings before or after emergence, causing uneven stands or death of plants before they are 2 in. high.

HOST RANGE

In New Zealand the disease occurs on field and garden peas. Elsewhere it has been recorded on sweet pea, perennial pea, vetch, and several other legumes.

FACTORS FAVOURING INFECTION AND SPREAD

Bacterial blight is carried over from one season to the next by infected seed. The causal organism does not survive in the soil once the host tissue has rotted. During the growing season the disease is spread by rain and insects. Infection takes place most readily during periods of wet weather and high humidity.

RESISTANT AND SUSCEPTIBLE VARIETIES

In tests carried out in New Zealand on varietal resistance the following varieties showed resistance to bacterial blight: Greencrop, Marathon, Giant Stride, Delwiche Commando, Merit, Wisconsin Perfection, English Wonder, and Duplex.

Varieties susceptible to the disease were as follows: Onward, Greenfeast, Stratagem, Alderman, Little Marvel, William Massey, Pioneer, Progress, Wisconsin Early Sweet, and Kelvedon Wonder.

CONTROL

The use of disease-free seed is the best means of avoiding infection. Where the disease is troublesome it is advisable to plant resistant varieties.

VIRUS DISEASES

PEA MOSAIC

Pea mosaic occurs throughout New Zealand, but is of economic importance only in certain localities, of which the seed-growing district of Marlborough is the most important. In this district the disease is present every season, infection in susceptible varieties ranging from 1% to nearly 100%. Surveys have shown that in some seasons the average incidence in susceptible varieties may be as high as 30% to 40%. In the Manawatu and Canterbury provinces, crops occasionally become severely infected and small areas have shown infections as high as 90%. In general, early sown crops show less mosaic, while percentage of infected plants is greatest at margins of fields and least at the centres.

In yield trials carried out by the Division, pea mosaic caused approximately 50% reduction in yield. Field observations suggest that yield reduction is often appreciably greater than this.



Photo H. Drake

Fig. 16.—Pea mosaic on garden pea var. Greenfeast. Leaf on right shows primary vein-clearing symptoms and that on left secondary mosaic mottling

SYMPTOMS

The first symptom is a clearing of veins on young leaves (Fig. 16, right). The network pattern thus produced is replaced later by a more general mottling in which light-coloured areas often occur in spaces between veins (Fig. 16, left). Mosaic-infected plants are stunted and pale in colour, while leaves are smaller than normal and occasionally slightly distorted. Symptoms appear on leaves developed after infection has taken place, so that plants that become infected late in the season show mosaic only on young leaves. Diseased plants flower later than healthy ones and pods are fewer in number, smaller, poorly filled, and late in maturing. Infection may occur at any stage of growth.

In some varieties, such as Yorkshire Hero, mottling is very pronounced, the light- and dark-green areas being large and clearly defined and leaves distorted (Fig. 17). On certain late varieties of luxuriant growth the disease causes a shortening of internodes, thus producing a marked stunting of plants.

HOST RANGE, METHOD OF SPREAD, AND OVERWINTERING

In addition to garden and field peas, pea mosaic attacks a number of plants including sweet pea, broad bean, blue lupin, red clover, subterranean clover, and gladiolus. Although in other countries, particularly the United States, the virus is reported to infect dwarf beans, it has not been found occurring naturally on this host in New Zealand.

Spread in the field is brought about by aphids, commonly known as green aphid, three species being responsible for spread in the Dominion. The disease is not carried in pea seed, but may spread from one locality to another in gladiolus corms, which are almost universally infected.

Pea mosaic frequently overwinters on red clover, but other susceptible clovers, blue lupins, and broad beans also serve to carry it through the winter. It readily overwinters, particularly in private gardens, in the corms of gladiolus.

RESISTANT AND SUSCEPTIBLE VARIETIES

A number of garden- and field-pea varieties are immune to attack by pea-mosaic virus. Not all varieties grown in New Zealand have been tested for susceptibility, but those that have been tested are included in the following lists of immune and susceptible varieties.

Garden Pea

Immune Varieties.—Autocrat.

English Wonder, Little Marvel,

Lord Chancellor, Onward, William Massey, and Witham Wonder.

Susceptible Varieties.—Alderman, Blue Bantam, Coronation, Giant Stride, Gladiator, Great Crop, Greencrop, Greenfeast, Laxton's Progress, Pioneer, Senator, Stratagem, Thomas Laxton, and Yorkshire Hero.

Field Pea

Immune Varieties.—Black-eyed Susan and Mackay.

Susceptible Varieties.—Austrian Winter, Blue Prussian, Early Blue, Harrison's Glory, Mansholt, Partridge, Unica, Victoria, White Ivory, and Zelka.

CONTROL.

Since, for field crops, the principal source of pea-mosaic infection is red clover, field plantings should not be adjacent to red-clover crops showing infection, or in fields where numerous infected red-clover plants are present on the headlands or roadsides. Infection is always greatest near the margin of fields, so, where possible, a crop should be grown in one large area rather than in several small ones. Observations in Marlborough suggest that incidence may be reduced by early planting. In field-scale garden-pea crops grown for canning or to supply local markets, losses through pea-mosaic can be avoided by use of immune varieties.

In many market and domestic gardens, susceptible plants are present throughout the year, and where pea mosaic occurs these carry the disease over from one crop to the next. It is therefore necessary to arrange plantings so that the garden is free from all susceptible hosts for a period of two to three months each year. Red-clover plants in the



Photo H. Drake

Fig. 17.—Pea mosaic on garden pea. Pronounced mosaic mottling on leaf of Yorkshire Hero

vicinity of the garden should be eradicated. Crops that carry infection should be removed and destroyed as soon as harvesting is completed. Gladiolus is the most dangerous source of infection in domestic gardens and should be grown as far from other susceptible hosts as possible. In localities where the disease is a problem, immune garden-pea varieties should be grown.

TOMATO SPOTTED WILT

Although tomato spotted-wilt is a serious disease of a number of crops in New Zealand, it is of only minor importance on peas. Incidence is greatest in Auckland, Hutt Valley, Christchurch, and Dunedin, but in no instance has infection substantially exceeded 5%. The disease has frequently been observed on a small percentage of plants in crops of garden peas, but has not been seen on field peas.

SYMPTOMS

The disease is characterized by development of purple or purple-brown markings on leaves, stems, and pods. On young leaves these may occur as numerous small spots or larger ring-spot markings. Older leaves often develop large necrotic areas (Fig. 18). Markings on stems take the form of longitudinal streaks, which usually appear on one side only and often extend for the length of the stems. As the disease progresses, the whole top of the plant is involved and eventually dies. Pods may show either



Photo R. I. Hughes

Fig. 18.—Tomato spotted-wilt on garden pea. Infected plant showing dark streaks on stem, discoloration and wilting of leaves, stunting of young growth, and flattening of pods



Photo R. I. Hughes

Fig. 19.—Tomato spotted-wilt on garden pea. Pods from infected plant showing flattening and discoloration. Two pods on left from healthy plant

spots or ring-spots, and if they are only beginning to form when infection takes place they may become flattened and discoloured (Fig. 19). When infection takes place on young plants the entire crop is lost, but on older plants only late pods are affected.

HOST RANGE, METHOD OF SPREAD, AND OVERWINTERING

Spotted wilt has a very wide host range, being recorded in other countries as attacking a large number of species in many families. The most important of the plants found to be susceptible in New Zealand are as follows: anemone, aster, black nightshade, buttercup, calendula, cape gooseberry, capeweed, chrysanthemum, cineraria, dahlia, garden pea, Iceland poppy, lettuce, nasturtium, schizanthus, thorn apple, tobacco, tomato, and zinnia. The disease is not seed carried, nor can the virus remain alive in dead plant debris. It is spread from plant to plant by thrips, transmission in New Zealand being confined to one species—the onion thrips.*

Spotted wilt will overwinter on susceptible perennial or winter-growing plants, the main hosts being garden ornamentals such as calendulas, chrysanthemums, dahlias, Iceland poppies, nasturtiums, etc. During the spring and summer, thrips migrate from such plants to peas, carrying infection with them.

* The adult of the onion thrips is a small, slender, brown to dark-brown insect approximately $\frac{1}{20}$ in. long. The young forms are usually light yellow and are wingless.

CONTROL

Tomato spotted-wilt is a particularly difficult disease to control, and unless the disease consistently causes appreciable losses it is doubtful whether the taking of special precautions is warranted. If, however, losses are consistently heavy the following measures should give some degree of control:

- (1) Grow pea crops as far as possible from flower gardens, tomatoes, lettuce crops, or commercial plantings of Iceland poppies and anemones.
- (2) Inspect plants at weekly intervals and remove and destroy all diseased plants.
- (3) Keep crop and headlands free from weeds, paying particular attention to eradication of black nightshade, buttercup, cape-weed, and thorn apple.



Photo H. Drake

Figs. 20.—Pea streak on garden pea. Note wilting of leaves and flattening and distortion of pods. Healthy plant on left

PEA STREAK

Pea streak is a minor disease of peas and appears to be of significance only in the vicinity of Palmerston North. In this area, where it sometimes causes losses in domestic gardens, an incidence of 50% has been observed on garden peas. The disease has also been found at Tauranga, but has not been seen elsewhere.

SYMPTOMS

Infected plants show wilting and death of leaves and dark streaks on stems. Growing points are killed and plants usually die within two or three weeks. Young pods remain flat and turn a dark purple-brown, while older pods develop purple-brown markings (Fig. 20).

HOST RANGE, METHOD OF SPREAD, AND OVERWINTERING

Pea streak has been found occurring naturally only on garden and sweet pea. No insect vectors are known. The virus is, however, highly infectious and may be spread from diseased to healthy plants by handling. Spread therefore occurs during staking and harvesting. The disease probably overwinters on susceptible clovers or leguminous weeds.

CONTROL

Pea streak has so far not been troublesome, other than in domestic gardens, where infected garden-pea or sweet-pea plants should be removed and destroyed immediately symptoms appear. After handling diseased plants, growers should wash their hands with soap and water to remove contamination.

PESTS

SLUGS AND SNAILS

These are the most serious pests of peas and frequently cause serious damage to garden peas, particularly in domestic gardens. They cause most damage to seedlings and young plants, and whole stands may be lost. These pests occur throughout the Dominion.

LIFE HISTORY AND HABITS

Slugs and snails are active under wet or humid conditions and consequently are troublesome at night, particularly in spring and autumn. In winter and in dry periods they remain quiescent.

The eggs are spherical, colourless, jelly-like, and semi-transparent. They are laid in clusters in the soil or under seed-boxes, flower-pots, or decaying vegetation, etc., in moist situations.

CONTROL

The best material to use for control is a bran and metaldehyde (e.g., meta) bait (see Table 3, page 25). In domestic gardens, bait should be placed in small heaps in the vicinity of the crop, and in wet weather these heaps should be protected from rain. To protect large areas, bait may be broadcast over the area. The bait, which should not be applied when rain appears imminent, may be slightly moistened before broadcasting to make it crumbly and friable.

OTHER PESTS

With the exception of slugs and snails, there are no major pests of either garden or field peas in New Zealand. However, the following pests may occasionally attack and cause damage to peas: green vegetable-bug, red spider-mite, red-legged earth mite, tomato fruitworm, and green aphid.

Green vegetable-bug is described on page 59 of this bulletin, red spider-mite on page 65, red-legged earth mite on page 66, and tomato fruitworm on page 53.

Damage caused by green aphid is similar to that caused by black aphid on broad beans, and control measures are the same (see page 73).

Dwarf and Runner Beans

Dwarf and runner beans (*Phaseolus vulgaris* L.) and beans of the Scarlet Runner type (*P. coccineus* L.) are practically universal in distribution, and constitute one of the important food crops of the world. In New Zealand these are grown extensively in market and home gardens for green beans, and also as field crops for canning and for seed. Seed crops are grown mainly in the Marlborough district. In the 1951-52 season, 117 acres of beans, yielding 6,333 bushels, were grown for seed.

The production of beans, as of many other crops, is greatly reduced annually by various diseases and pests. Because of their serious effect on yield and market value, these are a major factor in crop production. In the following section, diseases and pests occurring in the Dominion are described, and measures for their control recommended.

FUNGOUS DISEASES

ANTHRACNOSE

Anthracnose of beans, caused by the fungus *Colletotrichum lindemuthianum* (Sacc. & Magn.) Bri. & Cav., was first recorded in New Zealand in 1905. It is one of the most serious diseases with which growers have to contend, and has been recorded from all bean-growing areas in the Dominion. Both dwarf and runner bean varieties are attacked, but the latter are relatively resistant to the disease. Anthracnose is of economic importance in early and late crops of dwarf beans where 30% to 50% infection of pods is not uncommon. Where severe infection occurs, total loss of crop may result, while in less severe cases considerable losses may occur through reduction in yield and from unmarketable pods.

SYMPTOMS

The disease is usually first observed on stems of seedling

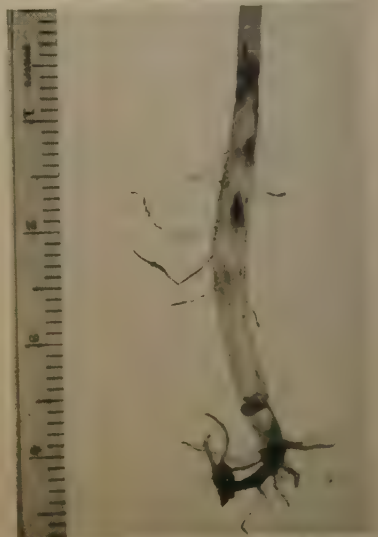


Photo L. Wright

Fig. 21.— Anthracnose: Showing infection on stem of bean seedling

plants, 3 in. to 4 in. high, as minute, dark, reddish-brown specks. These rapidly enlarge, becoming elongated, sunken, dark-brown lesions up to $\frac{1}{2}$ in. in length which later encircle the stem (Fig. 21). On the surface



Photo L. Wright

Fig. 22.—Anthracnose: Showing infection on dwarf-bean leaves. Left: undersurface; right: upper surface

of lesions, flesh-coloured spore masses are produced, containing large numbers of spores. When infection is severe, stems may be so weakened that plants collapse and die.

On leaves, infection occurs as small, dark-brown, angular dead areas on the upper surface, and as dark-brown to black lesions along the main veins on the undersides and on stalks (Fig. 22). On pods, the disease is first evident as small, circular, sunken, dark-brown spots about $\frac{1}{8}$ in. in diameter. As the spots enlarge, centres become lighter in colour and are surrounded by slightly raised, dark-brown to black margins (Fig. 23). Lesions may attain a diameter of approximately half an inch. Flesh-coloured to salmon-pink spore masses are formed in abundance on surface of spots (Fig. 24). When dry these



Photo S. Rumsey

Fig. 23.—Anthracnose: Infection on dwarf-bean pods

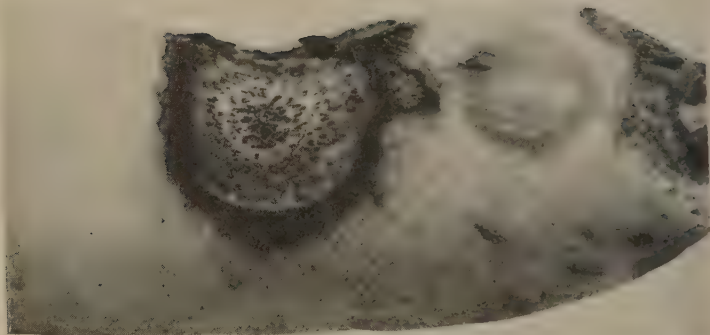


Photo by H. Drake

Fig. 24.—Anthracnose: Diseased area on bean pod showing fruiting bodies. $\times 6$



Photo L. Wright

Fig. 25.—Anthracnose: Infected areas on dwarf-bean seed

appear as grey, brown, or sometimes black pimples. On seed, the disease appears as small, dark-brown, almost circular, sunken spots from $\frac{1}{16}$ in. to approximately $\frac{1}{4}$ in. in diameter (Fig. 25).

FACTORS FAVOURING INFECTION AND SPREAD

Anthrachnose is disseminated mainly by means of infected seed. It can also survive in the soil on decaying organic matter for approximately two years. During the growing season the disease is spread from plant to plant by means of spores produced in large numbers on infected plants, and carried by rain, insects, and man to neighbouring plants. Rapid spread of infection and development of the disease is favoured by wet weather and temperatures of 60° F to 70° F. Dry weather checks spread, so that, in New Zealand, anthracnose is usually troublesome only in early and late crops.

RESISTANT VARIETIES

In tests for resistance, it was found that for the most part varieties resistant to halo blight (see page 47) were also resistant to anthracnose. Exceptions were Pale Dun, Canadian Wonder, Unrivalled Wax, Hawkesbury Wonder, and Oregon Giant, which were resistant to halo blight but susceptible to anthracnose. On the other hand, the varieties Keeny's Golden Wax, Masterpiece, Case Knife, Prizewinner, and Scarlet Runner were resistant to anthracnose but susceptible to halo blight.

CONTROL

As the disease is distributed mainly by infected seed, wherever possible only seed saved from clean crops should be sown.

There is no satisfactory seed treatment.

There should be an interval of two or three years between bean crops.

Spray trials in New Zealand have shown that the disease can be controlled by the application of copper sprays during the growing season. It is recommended that three applications of bordeaux mixture 6-8-100 or copper oxychloride (50% copper) 5 lb. in 100 gal. be made at fourteen-day intervals, commencing when plants are at the second-leaf stage.

In areas where the disease is troublesome and where spraying is not practicable, resistant varieties should be grown.

SCLEROTINIA DISEASE

Sclerotinia disease, also known as sclerotium disease, sclerotinia wilt, drop, or watery soft-rot, is caused by the fungus *Sclerotinia sclerotiorum* (Lib.) de Bary. It was first recorded on dwarf beans in New Zealand in 1927, and occurs in every district where beans are grown, but is usually more prevalent in northern areas. This disease has an extremely wide host range, being recorded on approximately sixty different host plants in the Dominion. It is sporadic in occurrence, and in the field is not normally of economic importance, but is sometimes troublesome in glasshouse crops, where 20% to 30% infection is not uncommon.

SYMPTOMS

The disease first appears as irregular, watersoaked areas on stems, followed later by similar spots on branches and leaves. These lesions rapidly enlarge, causing a soft, watery rot of infected tissues. During periods of warm, wet weather following initial infection, a white cottony growth of the fungus appears, in which are formed small, irregularly shaped, black bodies called sclerotia (Fig. 26). The sclerotia vary in size from about $\frac{1}{4}$ in. to $\frac{3}{8}$ in. in length. Where infection of stems is severe, plants are killed within a few days. The fungus may spread to pods, those in contact with the soil being most frequently attacked. In normal seasons when the disease is not severe, infection occurs on isolated plants throughout the field, but under conditions of severe infection large patches of plants may be attacked.

HOST RANGE

Besides beans, the disease attacks a wide range of plants in New Zealand. It frequently causes losses in such crops as cabbages, artichokes, lettuce, tomatoes, potatoes, and blue lupins.

FACTORS FAVOURING INFECTION AND SPREAD

The disease is carried over from season to season by means of the sclerotia, which are resistant to heat and cold, drought and moisture, and are able to remain viable in the soil for several years. In the spring, under favourable conditions of temperature and humidity, sclerotia germinate and produce spores (Fig. 27), which are carried by air currents to neighbouring plants. High humidity and wet soil conditions are factors most favourable for germination of sclerotia and development of spores. The optimum temperature for growth of the fungus lies between 60° F and 70° F. Sclerotia from infected crops other than beans may serve as a source of infection.

CONTROL

Plants should be adequately spaced both in and between rows. Lowering of humidity resulting from greater air circulation and penetration of sun's rays will check germination of sclerotia and spores,



Photo L. Wright

Fig. 26.—*Sclerotinia* disease: Infection on bean pods showing white fungous growth and sclerotia

and consequently lower infection. To reduce humidity further, the ground between plants should be well worked and all weeds removed. All diseased plants (both beans and other crops) should be removed immediately they are observed, and care taken that sclerotia do not fall to the ground. Infected plants should be burnt.

In the glasshouse, plants should be adequately spaced and the soil well cultivated. Humidity should be kept down by giving as much ventilation as possible and by avoiding excessive watering. All infected material should be removed and destroyed.

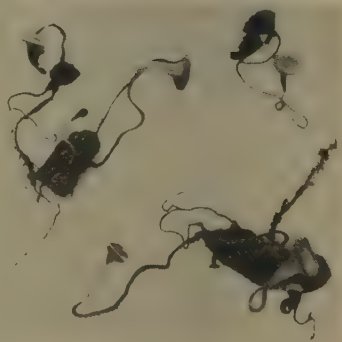


Photo H. Drake

Fig. 27.—Sclerotinia disease: Showing cup-shaped fruiting bodies growing from sclerotia

To prevent the disease from carrying over to the next crop, soil should be disinfected either by steam or Formalin 1–50 (for particulars see “Tomato Diseases and Pests in New Zealand and Their Control”, N.Z. *Dep. sci. industr. Res. Inf. Ser. 2*, 1949).

GREY MOULD

Grey mould or botrytis rot of beans is usually of minor importance in New Zealand, but occasionally causes losses both in field and glasshouse crops, and on beans in transit. It is caused by the fungus *Botrytis cinerea* Pers., a common wound parasite occurring on many different host plants. This fungus is present in most soils and occurs in all parts of the Dominion. It attacks stems, leaves, and pods, and is found mainly on dwarf-bean varieties.

SYMPTOMS

Plants may be attacked at any stage of growth. On stems and leaves, watersoaked, greenish-brown areas develop rapidly, causing wilting and death of plants. The most characteristic symptom of the disease is the presence of greyish-brown mould growth and spore masses, which are invariably formed on the surface of diseased areas. Pods are frequently infected, particularly where they are resting on the ground. They develop a slimy type of rot with characteristic grey-brown spore masses (Fig. 28).

FACTORS FAVOURING INFECTION AND SPREAD

Botrytis rot infects plants through injuries caused by adverse weather conditions, or through dead tissues. Low temperatures and high relative humidities are factors most favourable for infection. The fungus is

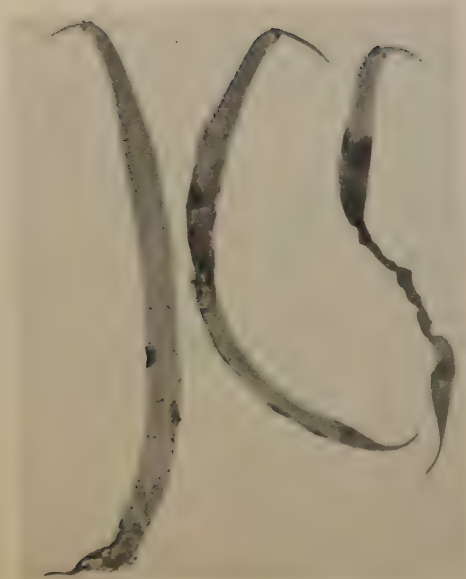


Photo M. J. Dahlberg

Fig. 28.—Grey mould: Infection on dwarf-bean pods



Photo L. Wright

Fig. 29.—Dry root-rot: Infected plant on left showing rot on roots and base of stem. Healthy plant on right

carried over in the soil by means of dark-brown or black, irregularly shaped resting bodies (sclerotia), and on infected plant refuse.

CONTROL

Plants should be adequately spaced and ground kept well cultivated. All infected material and plant refuse should be collected and burnt. Where the disease is troublesome, plants should be sprayed during the growing season with thiram at intervals of two or three weeks (see page 23).

In the glasshouse, humidity should be kept as low as possible and excessive watering avoided. Plants should be sprayed with thiram as above, commencing early in the season before the disease becomes established.

DRY ROOT-ROT

This disease is caused by infection of roots with *Fusarium solani* Mart.) var. *martii* (Appel & Wollenw.) f. 3 Snyd., a soil fungus which occasionally causes losses in bean crops. It occurs in all bean-growing areas in New Zealand but is not a disease of major importance.

SYMPTOMS

The first symptom of dry root-rot is a reddish discoloration of the tap root just before plants produce the first true leaf. The discoloration gradually extends until the whole tap root is covered, or it may occur in streaks extending almost to soil level (Fig. 29). Later, infected tissues become reddish-brown and small lateral roots are killed. Plants are retarded in growth, and with the advent of dry weather leaves turn yellow and frequently drop. Adventitious roots are often formed above lesions on tap roots just beneath the surface of the soil. If conditions for growth of plants are favourable, these secondary roots often keep the plant alive and allow it to produce a crop, but yield is considerably reduced.

FACTORS FAVOURING INFECTION AND SPREAD

The fungus is carried over from season to season in the soil, and can survive almost indefinitely. The disease is not carried within the seed, but spores may be carried on the surface of the seed. Drainage water and run-off during heavy rains are important means of dissemination of the fungus from one area to another. Infection occurs over a wide range of soil temperatures from 60° F to 90° F, being most severe at about 72° F.

CONTROL

As the fungus can remain alive indefinitely in the soil on decaying organic matter, crop rotation should be practised to reduce infection. Seed should be dusted before sowing with thiram, Spergon, or Tetroc (see page 13). All refuse from an infected crop should be burnt after harvesting and not ploughed in.

BEAN RUST

Bean rust, caused by *Uromyces appendiculatus* (Pers.) Link. was first identified in New Zealand in April 1951 on late crops of dwarf and runner beans (varieties Sydney Wonder, Kentucky Wonder, and Fardenlosa) from market and home gardens in Auckland. In 1952 the disease first appeared in March on Fardenlosa and Market Wonder beans in the Mangere district, and during April infection was general on most late crops. In most cases infection was slight, affecting only the older leaves, but in some crops foliage was severely damaged and yields considerably reduced. The disease has been found in the vicinity of Auckland, and has also been reported from New Plymouth.

SYMPTOMS

The bean-rust fungus attacks leaves, pods, and, occasionally, tender parts of stems. It is most abundant on leaves, and first appears as minute, light-coloured, slightly raised spots or pustules. These usually appear first on undersides of leaves, but later are abundant on both surfaces (Figs. 30 and 31). Pustules gradually increase in size and

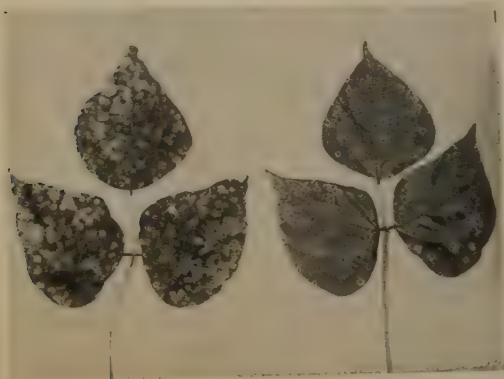


Photo S. Rumsey

Fig. 30.—Bean rust: Showing heavy infection on leaves of runner bean. Left: upper surface; right: under surface



Photo S. Rumsey

Fig. 31.—Bean rust: Showing pustules on runner-bean pods

may attain a diameter of $\frac{1}{16}$ in. to $\frac{1}{12}$ in. After a few days the enlarging pustules rupture and expose light-brown, rust-coloured spore masses. When heavy infection occurs, a ring of secondary pustules often develops outside the original pustule. Severely infected leaves become shrivelled and later fall from the plant. When plants mature and leaves commence to die, the spore masses turn dark-brown to black, as another stage of the fungus develops.

FACTORS FAVOURING INFECTION AND SPREAD

Bean rust is disseminated mainly by wind-blown spores, which are carried over long distances. Spores are produced in large numbers on infected plants and will germinate as soon as they are mature. Under



Photo S. Rumsey

Fig. 32.—Bean rust: On left, susceptible variety; on right, resistant, following artificial inoculation

favourable conditions they can produce further generations of spores in ten to fifteen days. Overwintering spores, which are formed in the late stages of the disease, require a dormant period before germination, and can retain their viability for more than six months. These spores serve to carry over the fungus from year to year on dead leaves and other bean refuse that have not been destroyed or ploughed in. They can also overwinter on stakes taken from an infected crop.

The optimum temperature for infection is approximately 62° F. Infection can take place only under conditions of very high humidity.

HOST RANGE

In other countries, bean rust has been recorded on a number of bean species, but in New Zealand it has been found only on dwarf and runner beans.

RESISTANT VARIETIES

During the season 1952–53, forty-one varieties were tested for resistance to rust. Of these, only two varieties, Westralia (Fig. 32), a runner variety recently developed in Western Australia, and Fullgreen, a dwarf variety raised in the United States, were resistant.

CONTROL

As the disease is carried over from season to season on infected material, all bean refuse from an infected crop should be destroyed by burning, or completely buried in the soil.

Stakes from an infected crop should be disinfected by immersing in 8% copper sulphate solution or lime sulphur 1-10.

Where infection occurs, plants should be sprayed with lime sulphur 1-200 plus colloidal sulphur 2 lb. in 100 gal. Several applications at intervals of two to three weeks may be necessary, according to severity of infection (see page 23).

PRE-EMERGENCE DAMPING OFF AND SEEDLING WILT

This disease occurs only on seedlings either before or after emergence from the soil. It is caused mainly by the common soil fungus *Pythium ultimum* Trow., which is responsible for seedling damping off of many plants in New Zealand. Under conditions of low soil temperatures (50° F to 60° F) and high soil moisture content the fungus attacks seedlings at base of stems near the roots and extends into the tap and lateral roots, forming soft, watersoaked lesions, and brown discoloration of internal tissues. Leaves of infected seedlings wilt, and later the stems collapse and plants die. Plants are no longer susceptible to infection when stems become woody.

CONTROL

This disease can be controlled by dusting the seed with thiram, Spergon, or Tetroc before sowing (see page 13).

BACTERIAL DISEASES

HALO BLIGHT

Halo blight, caused by *Pseudomonas phaseolicola* (Burkholder) Dowson, has been present in New Zealand for over twenty years. As halo blight is seed carried, it occurs throughout the Dominion. It is the most serious disease of beans in New Zealand and causes losses in all districts. This disease is present in all countries where dwarf or runner beans are grown. Although, in general, symptoms of halo blight are distinctive, some may be confused with those of bean anthracnose (see page 34). Infection is seed carried, but diseased seed is not distinguishable from healthy seed.

SYMPTOMS

(a) *Seedlings*.—The first symptoms to develop from seed-borne infection are watersoaked or brown spots on stems of seedling plants (Fig. 33). These spots normally exude drops of bacterial ooze. Seedling plants infected from the seed remain small and are rarely observed by growers. They usually turn dark-brown and die before true leaves are formed.

(b) *Leaves*.—The first obvious symptoms appear on the twin leaves as dark-green, shining, angular spots approximately $\frac{1}{16}$ in. in diameter (Fig. 34). Spots develop on both leaf surfaces and are usually present in large numbers. When only a few spots are present they are sometimes



Photo H. Drake

Fig. 33.—Halo blight: Effect of seed-carried infection. Withered cotyledon leaves and stem lesions on dwarf-bean seedling



Photo H. Drake

Fig. 34.—Halo blight: Primary leaf infection on dwarf-bean seedling

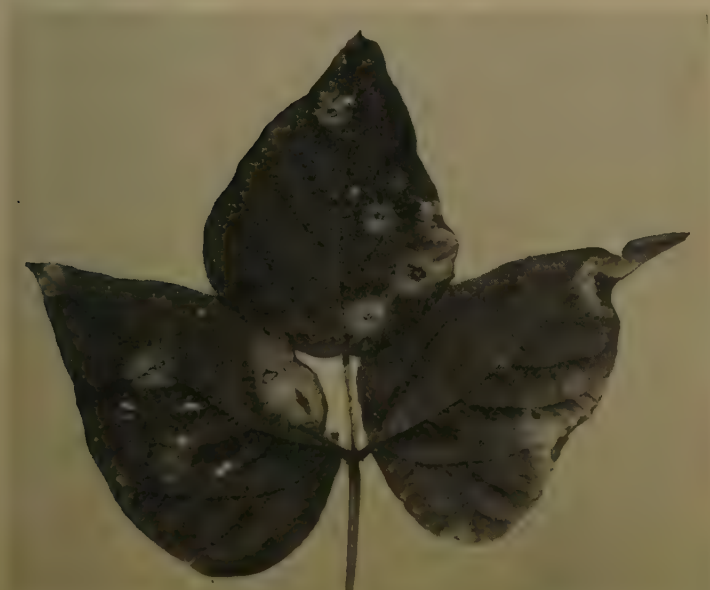


Photo L. Wright

Fig. 35.—Halo blight: Showing infection with typical halos on bean leaves

surrounded by circular zones lighter in colour than the normal leaf. On older, rapidly growing plants, symptoms on leaves are more conspicuous, though the number of infection points is usually less than on the first leaves. The spots are similar in appearance, but are usually surrounded by circular, bright-yellow halos, $\frac{1}{8}$ in. to $\frac{1}{4}$ in. in diameter (Fig. 35). It is from this symptom that the disease derived its name.

Halos are most conspicuous when only a few spots are present on each leaf. Infections near the margins cause distortion of leaves.

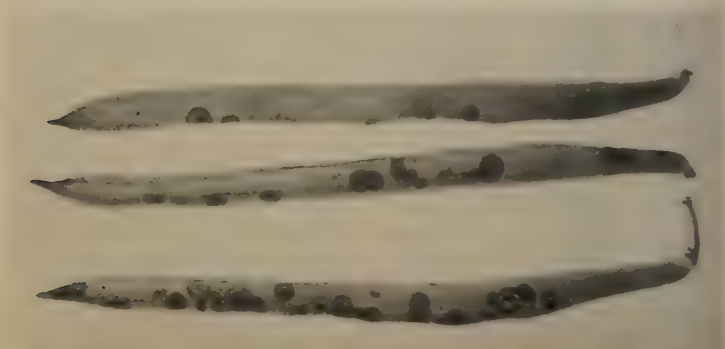


Photo L. Wright

Fig. 36.—Halo blight: Infection on dwarf bean pods. Note bacterial ooze on some lesions.

(c) *Stems*.—Symptoms at first consist of small, water-soaked spots slightly darker than the surrounding stem. In young plants the bacteria progress rapidly, causing reddish-brown, sometimes slightly depressed, elongated areas. In wet or humid weather bacteria ooze from these areas and later dry out as a greyish-white incrustation.

(d) *Pods*.—The first sign of infection on pods is the development of small, water-soaked, circular spots $\frac{1}{8}$ in. to $\frac{1}{4}$ in. in diameter. Within a few days they increase in size to approximately $\frac{3}{8}$ in. and become dark green. In moist weather, bacterial ooze is exuded from the spots, giving them a slimy appearance (Fig. 36). Later this bacterial slime dries and forms a grey film over the surface. In mature pods the lesions become dark brown, and though not sunken as in anthracnose they can be confused with those caused by the latter disease. The yellow halos that are so characteristic on leaves do not occur on pods.

HOST RANGE

In New Zealand, halo blight attacks dwarf and annual and perennial runner beans. In other countries it has also been recorded on several closely related legumes.

FACTORS FAVOURING INFECTION AND SPREAD

The disease is seed carried and thus it is readily distributed and carried over from one season to the next. Within a crop the disease is spread by rain splashing and by insects, which carry bacterial ooze. As the percentage of seedlings growing from infected seed is usually low,

there are comparatively few infected centres in a crop. Infection spreads from these centres to form patches of diseased plants. Under conditions favourable for disease development, halo blight spreads rapidly throughout the crop. During periods of high humidities and temperatures, symptoms appear on plants approximately one week after infection has taken place. In seed crops when beans follow beans in a rotation the disease may be introduced into the new crop by volunteer plants grown from infected seed.

VARIETAL RESISTANCE

Bean varieties vary greatly in their susceptibility to halo blight, some being highly resistant. Tests carried out in New Zealand with a large number of dwarf and runner bean varieties showed that, in general, white-seeded varieties and runner varieties were the most resistant. The following list indicates the relative resistance to pod infection of varieties commonly grown in the Dominion. Some of the varieties listed as resistant may show infection on leaves.

Dwarf Beans

Resistant Varieties.—Burnley Selection of Canadian Wonder, Early White (= Sydney Wonder), Feltham's Prolific, Golden Wax, Haricot varieties, Pale Dun, Refugee, and some strains of Woods Centenary.

Susceptible Varieties.—Black Prince (= Black Valentine), Brown Beauty, Masterpiece (= Matchless), Pencil Pod Wax, Stayley's Surprise (= The Prince), Stringless Greenpod (= Tendergreen), and Surecrop Stringless Wax (= Bountiful Wax or Golden Butter).

Runner Beans

Resistant Varieties.—Epicure (= Everbearing Stringless), Kentucky Wonder (= Homestead), Market Wonder (= Fardenlosa or Delicious), Scarlet Runner (= Streamliner), and White Kentucky Wonder.

CONTROL

The disease is best prevented by use of disease-free seed and rotation of crops. If infection does take place, efficient control can be obtained by immediately spraying with either copper oxychloride or bordeaux mixture (see page 22). The latter material may cause slight spray damage, with consequent slight reduction in yield.

Spraying should commence when the first true leaves have appeared. In normal seasons three sprays at approximately monthly intervals will give good control. In dry seasons only two sprays are necessary. For seed production, when control must be very complete to prevent any seed from becoming infected, four sprays should be applied.

In market and domestic gardens, satisfactory control can be secured by growing resistant varieties.

In market gardens, crop rotation should be practised and successive plantings isolated as much as possible.

Crop rotation should also be practised with field crops grown for seed production to avoid carry over of the disease on volunteer plants.

VIRUS DISEASES

BEAN MOSAIC

Bean mosaic occurs on dwarf and runner beans throughout New Zealand, but incidence varies in different localities. For instance the disease is less serious in Auckland Province than in southern districts.

On dwarf beans, 50% infection is common in the Manawatu and South Island, and 90% has been observed in some crops. In most varieties, reduction in number and size of pods resulting from infection causes over 50% loss in yield.

Although the disease is not as prevalent in runner as in dwarf beans, reduction in yield of individual plants is much greater, the crop produced being negligible.

SYMPTOMS ON DWARF BEAN

Symptoms vary with the variety, age of plants, and environment. On the first leaves to show symptoms the veins sometimes turn dark green, while the remainder of the leaf becomes light green or yellow. Leaves formed after infection may show (a) a general diffuse mottling, (b) a well defined mosaic pattern in which the darker green areas make greater growth, producing a savoy appearance; or they become paler, more pointed, and slightly narrower than normal and show extensive dark-green areas associated with the veins (Fig. 37). Sometimes leaves are misshapen and show a downward rolling at the edges and tips (Fig. 38), but often there is little distortion. Infected plants are pale



Photo H. Drake

Fig. 37. Bean mosaic on Canadian Wonder dwarf bean. Leaf showing pointed leaflets and dark-green areas associated with main veins



Photo H. Drake

Fig. 38. Bean mosaic on Canadian Wonder dwarf bean. Comparison of healthy and infected plants growing in 6 in. flower pots

and slightly stunted (Fig. 38); they set fewer and smaller pods than do healthy plants.

Frequently plants that have shown well defined symptoms on the lower leaves are apparently healthy or show only mild symptoms on young growth. In the field there is a gradation from pronounced to very mild symptoms, and on some varieties it is often difficult to determine from observation whether or not a plant is infected.

SYMPTOMS ON RUNNER BEAN

Leaves are small, curled, and distorted, with a pronounced mosaic mottling in which the dark-green areas are raised, giving the appearance of blisters (Fig. 39). Infected plants are much stunted, vines being spindly and the number of leaves reduced. The few pods formed are small and contain fewer seeds than those of healthy plants.



Photo H. Drake

Fig. 39.--Bean mosaic on Case Knife runner bean. Distortion and dark-green blister-like areas on leaf. Healthy leaf on left

HOST RANGE, METHOD OF SPREAD, AND OVERWINTERING

In New Zealand, bean mosaic occurs only on dwarf and runner beans. Spread of the disease in the field is brought about by aphids, of which the bean aphid (see page 73) is the most important. The virus is seed carried, and this is the main method by which it carries over from one season to the next. It can also overwinter on perennial runner beans. In some localities, especially Auckland, where bean aphid appears to be scarce, there is little spread and, provided the one line is maintained, incidence becomes less each season until finally the disease disappears.

VARIETAL RESISTANCE

There are considerable differences in the susceptibility of different bean varieties to bean mosaic, and in North America the use of resistant varieties has played a major role in control of the disease. Trials in New Zealand have shown that some resistant varieties from North America are also resistant here, but no information is available regarding the relative susceptibility of varieties commonly grown in the Dominion.

CONTROL

Two methods of control are possible:

Use of resistant varieties. These could either be secured from overseas, or varieties suitable for our conditions could be bred or selected in New Zealand.

Production of mosaic-free seed. Crops could be grown in localities such as the Auckland district, where spread is slow, and infected plants rogued. In this way a nucleus of mosaic-free seed could be obtained within two or three seasons and bulk supplies grown under isolation in normal seed-producing areas.

PHYSIOLOGICAL DISEASES

In this group are included those abnormal conditions not attributable to any pathogen. Some are caused by damage brought about by climatic or harvesting conditions; others are heritable. In the former are baldhead and sunscald, and in the latter mottle leaf, yellow spot, and blister pod.

BALDHEAD (Fig. 40)

Baldhead usually occurs in a few plants shortly after emergence from the soil, when the terminal shoot of each plant fails to develop. Such plants may remain stunted or produce weak shoots from axils of cotyledons. The condition arises from seed injury at time of mechanical harvesting, the number of affected plants being in proportion to the extent of seed injury. Seed injury varies from minute cracks to extensive damage of the seed coat. All varieties of beans can be affected.

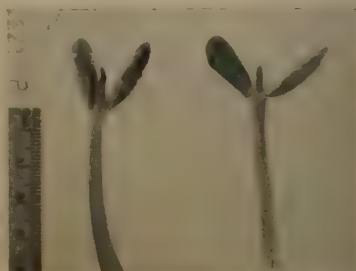


Photo J. Endt
Fig. 40.—Baldhead: Bean seedlings showing failure to form secondary leaves



Photo H. Drake

Fig. 41 (a).—Sunscald: Symptoms on bean pods



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Photo J. Endt

Fig. 41 (b).—Sunscald: Symptoms on bean leaf



Photo J. Endt

Fig. 42 (a).—Mottle leaf: Symptoms on runner-bean leaf



Photo L. Wright

Fig. 42 (b).—Mottle leaf: Showing variegation and distortion on dwarf-bean leaf

SUNSCALD (Fig. 41 (a) and (b))

Sunscald occurs both on foliage and pods, particularly of dwarf varieties. On leaves, sunscald causes irregular, brown, necrotic areas which sometimes affect more than half the area of young leaves. On pods, the surface shows dark-brown spots or flecks, or extensive areas of dark-brown tissue. In early stages the spots are watersoaked in appearance and can be confused with halo blight. The brown areas are not sunken, and regularly occur on the side of pod exposed to the sun. Most varieties are affected.

MOTTLE LEAF (Fig. 42 (a) and (b))

The leaves show variegation due to variation in chlorophyll distribution; some leaves show mottling not unlike symptoms of virus infection, or have large areas paler in colour than the normal leaf, and some leaves are distorted. These conditions are believed to be heritable. They do not cause appreciable loss in plant vigour. Dwarf and runner varieties are affected.

YELLOW SPOT (Fig. 43)

This also is a heritable condition. It is characterized by a chlorophyll deficiency occurring as small yellow spots most noticeable on the compound leaves. The amount of spotting and intensity of yellowing varies. Most varieties show a few plants so affected.

BLISTER POD (Fig. 44)

The pods show varying numbers of minute pimples each surrounded by a narrow dark zone. The condition can be confused with early symptoms of halo blight. The cause is not known. Only a few varieties, including Epicure, are affected.



Fig. 43.—Yellow spot: Symptoms on bean leaf



Fig. 44.—Blister pod:
Pods showing small
pimples

PESTS

The insect pests of beans can be divided into two main categories (1) chewing insects and (2) sucking insects.

Chewing insects have biting mouthparts with which they chew plant tissues, while sucking insects either pierce the tissues and suck up the sap, or rasp the leaf surface and imbibe exuded sap. Piercing-sucking insects insert thread-like stylets or mouthparts into the tissues and withdraw sap through these. Rasping-sucking insects break the surface of the leaf with their solid stylets and feed on exuded sap. Feeding habits largely determine the type of insecticide used for control, stomach poisons being used for chewing insects and contact poisons for sucking insects.

In this account, insects are grouped according to their methods of feeding. Pests other than insects are included in a "Miscellaneous" section.

(1) CHEWING INSECTS

CATERPILLARS

Looper caterpillar (*Plusia chalcites* Esp.) (Fig. 46 (a)) is the main caterpillar pest of beans in New Zealand, although the tomato fruitworm (*Heliothis armigera* Hubn.) may occasionally be found on them (Fig. 45). The following account relates to the looper caterpillar.

IMPORTANCE, TYPE OF INJURY, AND DISTRIBUTION

The looper caterpillar is one of the major pests of beans in the Dominion.

The presence of this pest is readily recognized by holes eaten in the leaves (Fig. 46 (b)). Large areas of foliage may be devoured, with consequent reduction in vigour of plants. Young pods are also attacked, and, when infestation is heavy, losses through destruction of pods may be serious. Infestation increases during the season, with the result that the greatest damage occurs in late summer. The caterpillars can readily be found on plants showing damage.

Plants attacked include bean, tomato, potato, black nightshade, dahlia, salvia, geranium, mint, and many other plants.

The pest is present throughout the North Island and the northern portion of the South Island.

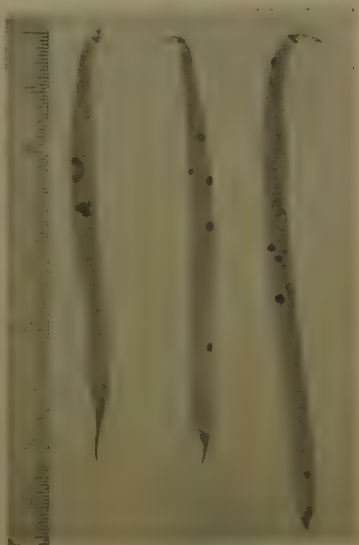


Photo M. J. Dahlberg

Fig. 45.—Beans damaged by tomato fruitworm, *Heliothis armigera*

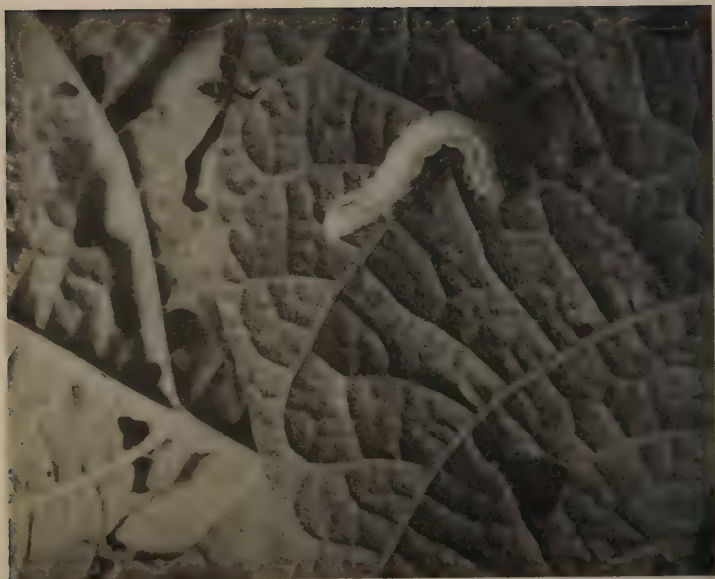


Photo B. B. Given

Fig. 46 (a).—Caterpillar of *Plutia chalcites* on bean leaf

APPEARANCE, LIFE HISTORY, AND HABITS

The adult of the looper caterpillar is a dark-brown nocturnal moth measuring approximately $1\frac{1}{2}$ in. across the wings; in the centre of each forewing there are two golden spots very close together (Fig. 47). The female is capable of laying up to five hundred eggs, which are white and are usually laid singly on the undersides of leaves. In summer they hatch in seven to ten days into green caterpillars, which are usually found on the undersides of leaves; these progress with a looping movement, hence the name "measuring worms". When disturbed, the caterpillar has a habit of raising the forepart of the body and waving about in wide sweeps. In summer the caterpillar attains its full length of $1\frac{1}{4}$ in. to $1\frac{1}{2}$ in.



Photo M. J. Dahlberg

Fig. 46 (b).—Bean leaves damaged by the looper caterpillar, *Plutia chalcites*



Photo L. Wright

Fig. 47.—Adult of the looper caterpillar, *Plusia chalcites*

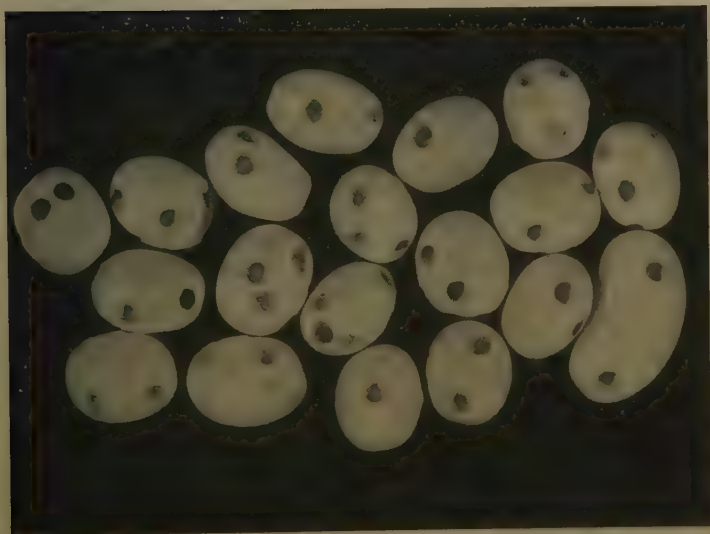


Photo W. E. Barnard

Fig. 48.—Bean seed damaged by the bean weevil, *Bruchus obtectus*

in four to six weeks, then forms a brown pupa enclosed in webbing of fine silken threads woven as a shelter on the undersides of leaves. The pupal stage occupies ten to fourteen days. The whole life cycle occupies seven to nine weeks, and in the northern part of New Zealand there may be several generations each year.

CONTROL

Commencing when caterpillars first appear, spray plants at intervals of ten to fourteen days with DDT (see page 23). To avoid poisonous residues on harvested beans, sprays should not be applied when pods are maturing.

Keep down weed growth to reduce infestation.

BEAN WEEVIL (*Bruchus obtectus* Say.)

Bean weevil is a serious pest of bean seed in the northern portion of the North Island, where infestation often causes total loss of seed during storage. Elsewhere in New Zealand it is of minor importance.

TYPE OF INJURY

Frequently infestation with bean weevil is not observed until seed is removed from storage, although it is sometimes evident at threshing. Infestation is readily detected by the presence of small round holes approximately $\frac{1}{8}$ in. in diameter (Fig. 48), through which the adult weevils have emerged. If seed is stored in a fairly warm place there may be several generations during the winter, so the longer the storage period the more extensive is the damage. Severely damaged seeds fail to germinate.

APPEARANCE, LIFE HISTORY, AND HABITS

The adult weevil is grey and about $\frac{1}{8}$ in. long. The wing cases do not cover the whole of the back (Fig. 49), but leave the apical portion of the reddish-brown abdomen exposed. Just before harvest the female lays eggs in holes or crevices on the pods. These hatch, and the larvae enter the seeds before the beans are harvested. In store they develop into adults which cut their way through the seed coat at emergence. In Auckland the duration of the life cycle in winter has been found to be approximately six weeks. The bean weevil infests only bean seed.



Photo J. Endt

Fig. 49.—Adult bean weevil, *Bruchus obtectus*

CONTROL

Thresh beans as soon as possible after pods have been harvested and treat seed immediately with a dust containing DDT or lindane (see page 13).

If infestation occurs at a later stage on untreated seed, dusting with DDT or lindane will prevent further damage. Under these circumstances, however, treatment is worth while only when infestation is slight.

Untreated infested seed should not be sown as germination will be poor and the weevil is introduced into the field to infest the resulting crop.

SOIL COLLEMBOLA OR SPRINGTAILS

The species of Collembola most commonly concerned in causing damage is *Onychiurus armatus* Tullbg., which occurs throughout New Zealand. Under cold wet conditions it may cause considerable losses.

TYPE OF INJURY

Infestation with Collembola results either in failure of seedlings to appear above ground or in development of weak plants. The cotyledon leaves of affected seedlings that do emerge are pitted with small brownish-coloured holes, which are the feeding marks of the insects (Fig. 50). Secondary leaves may fail to develop.

Injury is fairly common under cold wet conditions when beans are slow in germinating. When germination and growth are rapid, plants become established before the insects can cause damage.



Photo D. Read, Cawthron Institute

Fig. 50.—Cotyledons and roots of germinating beans damaged by the feeding of soil Collembola

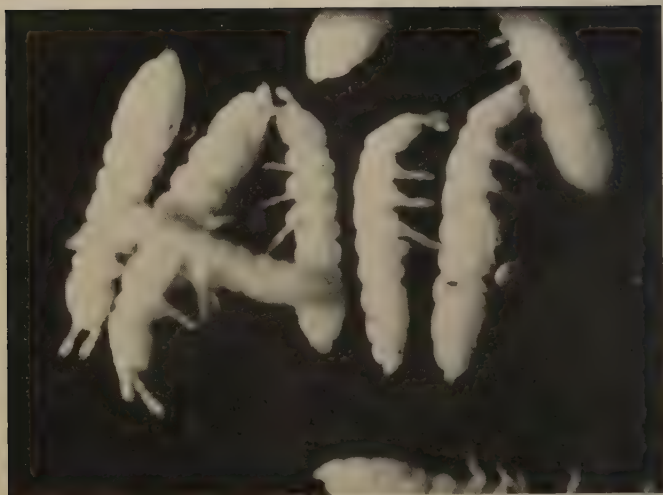


Photo S. A. Rumsey

Fig. 51.—Soil Collembola. $\times 35$

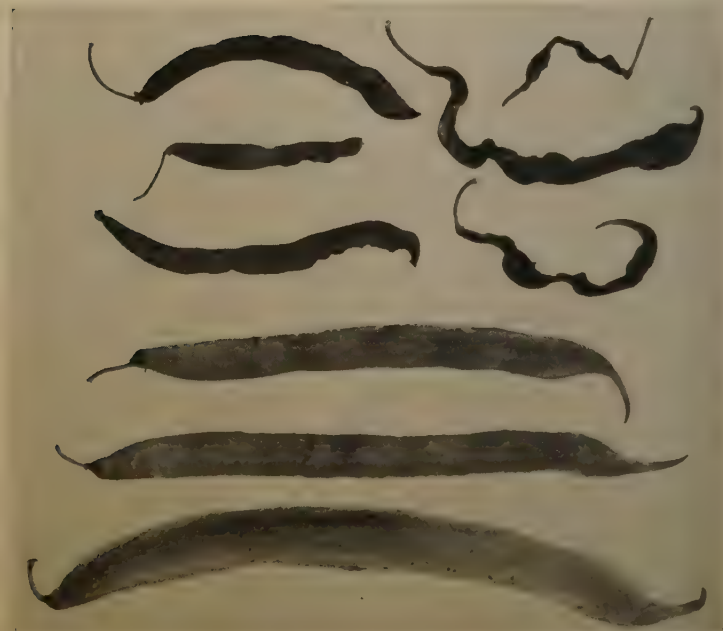


Photo S. A. Rumsey

Fig. 52.—Bean pods damaged by the green vegetable-bug, *Nezara viridula*. Top, damaged. Bottom, undamaged

APPEARANCE AND HABITS

The insects, which are white and elongated ($\frac{1}{25}$ in. to $\frac{1}{16}$ in. long) will be found in the soil round damaged plants (Fig. 51). Collembola move with quick jerky movements. They are generally found in damp situations, and as well as occurring in the soil they may be found beneath rotting vegetation such as heaps of lawn cuttings.

CONTROL

Where the pest occurs, water the soil heavily around germinating seedlings with nicotine sulphate plus soft soap (see page 24).

(2) SUCKING INSECTS

(a) PIERCING-SUCKING INSECTS

GREEN VEGETABLE-BUG (*Nezara viridula* L.)*

The green vegetable-bug is present in most parts of the North Island and also occurs in the Blenheim and Nelson districts of the South Island. Infestation may be heavy, particularly in northern areas, where total loss of bean crops sometimes occurs.

TYPE OF INJURY

When infestation is heavy, loss of sap causes stunting of plants. If the insects are numerous during the pod stage, the pods may be malformed or even withered (Fig. 52).

HOST RANGE

In addition to beans, the green vegetable-bug attacks peas, clovers, tomatoes, potatoes, tree tomatoes, silver beet, pumpkin, marrow, maize, sweet corn, and many other useful plants as well as numerous weeds.

APPEARANCE, LIFE HISTORY, AND HABITS

The adult is green, shield-shaped, approximately $\frac{1}{2}$ in. long by $\frac{3}{8}$ in. wide, and flattened (Fig. 53). About one-third of the distance along the back from the head end there is a transverse groove, and on the mid-portion of this are three small white spots. This pattern of spots is characteristic.



Fig. 53.—Adult green vegetable-bug, *Nezara viridula*

*The green vegetable-bug can be confused with a native shield-bug (*Zangis amyoti* White) which is much the same colour, shape, and size, but lacks the pattern of three white spots on the back. It is not a pest.



Photo S. A. Rumsey

Fig. 54.—Eggs of the green vegetable-bug, *Nezara viridula*



Photo S. A. Rumsey

Fig. 55.—Top: Adult (left) and two immature forms of the green vegetable-bug, *Nezara viridula*.
Bottom: Adult (left) and two immature forms of the native shield-bug, *Zangis amyoti*

The female lays a cluster or raft of sixty to eighty somewhat barrel-shaped eggs (Fig. 54) on the undersides of leaves. The nymphs, when first hatched, are orange in colour, but rapidly change to a shining black. They cast their skins or moult five times before becoming adults. The colour of immature forms (Fig. 55) is predominantly black with spots of cream or light yellow on the abdomen and patches of red on the fore-part of the body.

The winter is passed in the adult stage beneath long grass, weeds, and hedges. In the spring they emerge and the female lays its eggs. In the northern part of the North Island it has been found that eggs hatch in approximately three weeks, and it has been estimated that the life cycle occupies about sixty to one hundred days. Under these conditions it is probable that there are three generations a year. The adults fly readily and can travel considerable distances.

When crushed, the insect emits an evil-smelling liquid.

CONTROL

Where the pest is troublesome, spray with HETP or TEPP (see page 24). These materials rapidly break down into non-toxic ingredients, and consequently beans may be harvested and eaten twenty-four hours after treatment.

During the autumn and winter, weeds and plant debris in which the insects hibernate should be eliminated as thoroughly as possible.

In small gardens, considerable benefit may be secured by hand picking and destroying insects and egg rafts, particularly in spring, when overwintering adults become active, mate, and lay eggs.

ROOT APHID (*Trifidaphis phaseoli* Pass.)

Root aphid has been recorded only from the North Island and causes damage only in the warmer areas. It is of minor economic importance.

TYPE OF INJURY

Infested bean plants, particularly dwarf beans, become yellowed and unthrifty and sometimes wilt. When the plants are dug up, the aphids are found to be clustered on the roots (Fig. 56).

HOST RANGE

In New Zealand this pest has been found also on tomatoes, potatoes, and carnations.

APPEARANCE, LIFE HISTORY, AND HABITS

The insects are approximately $\frac{1}{12}$ in. long (about the size of a pin-head), globular, and greyish-white. They excrete considerable quantities of liquid honeydew, and for this reason colonies are often attended by large numbers of black ants, which feed on this sweet fluid. In the adult stage there are wingless and winged individuals, the latter being responsible for distribution of the pest.

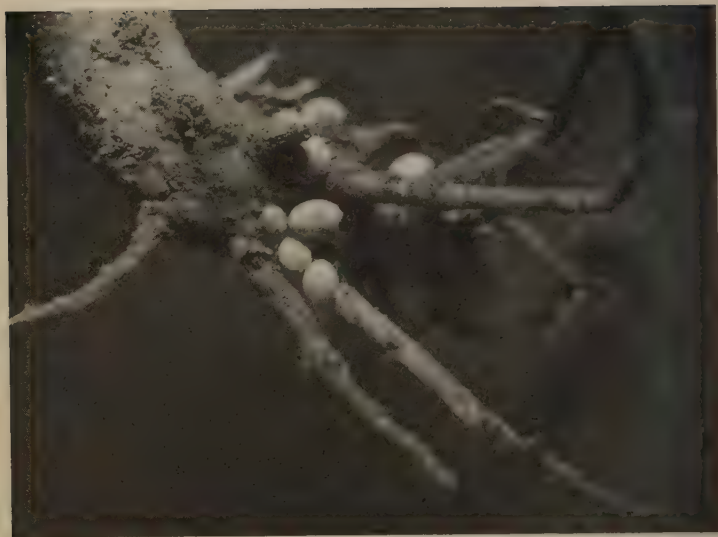


Photo M. J. Dahlberg

Fig. 56.—Bean root with root aphids, *Trifidaphis phaseoli*

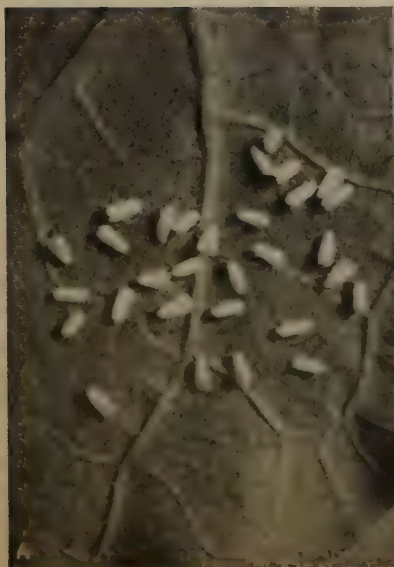


Photo B. B. Given

Fig. 57 (a).—Adult white fly, *Trialeurodes vaporariorum*

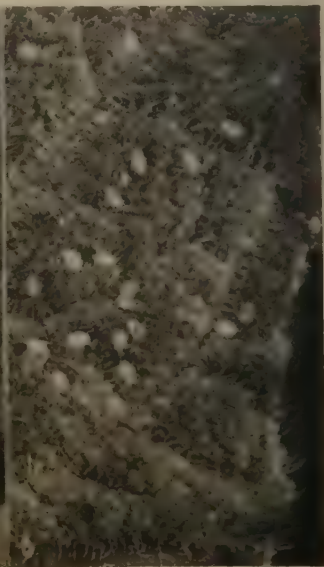


Photo E. B. Given

Fig. 57 (b).—Immature forms of the white fly, *Trialeurodes vaporariorum*

CONTROL

Water the soil round infested plants with nicotine sulphate plus soft soap or with lindane (see page 24).

WHITE FLY (*Trialeurodes vaporariorum* Westw.)

White fly, which occurs throughout the Dominion, is of importance on beans only in glasshouses.

TYPE OF INJURY

Infested plants become pallid, assume an unthrifty appearance, suffer lack of vigour, and in severe cases may wilt and die. If plants are disturbed, numerous small white flies rise in the air, and examination of undersides of leaves reveals the presence of many tiny, flat, scale-like insects that are immature stages of the pest. The insects excrete quantities of honeydew, and a black fungus that grows on this gives damaged plants an unsightly appearance.

HOST RANGE

In New Zealand, white fly has been found to attack beans, tomato, cucumber, begonia, geranium, ferns, hisbiscus, cineraria, and many other plants.

APPEARANCE, LIFE HISTORY, AND HABITS

The adults (Fig. 57 (a)) are small moth-like insects approximately $\frac{1}{25}$ in. long, covered with a fine, white, powdery substance. Usually they remain on the undersides of leaves, but on hot days may be seen fluttering about the plants. The female lays eggs on undersides of leaves, and during the summer these hatch in about fourteen days. The small, scale-like insect that emerges from each egg increases in size until at full growth it is roughly oval, flattened, and of glassy appearance (Fig. 57 (b)). The length of the life cycle varies with the temperature, but in summer occupies about a month.

As the immature forms are inactive and adult flies have a habit of congregating while feeding, spread of the pest is comparatively slow.

CONTROL

If this pest is detected on beans in a glasshouse, spray or fumigate with nicotine sulphate (see page 24).

As white fly can survive on a very wide range of plants, glasshouses should be kept clean-cultivated between crops.

(b) RASPING-SUCKING INSECTS

GREENHOUSE THRIPS (*Heliothrips haemorrhoidalis* Bouché)

Greenhouse thrips, a minor pest of beans, occurs throughout New Zealand.

TYPE OF INJURY

Silvered or whitened areas appear on the foliage of infested plants. Tiny black spots of excrement that are characteristic of the pest may be seen on the silvered areas. In cases of severe infestation, foliage may dry up and wither. Small, black and white insects are present on damaged areas.

HOST RANGE

The greenhouse thrips also infests citrus, rhododendron, azalea, peas, and many other plants.

APPEARANCE, LIFE HISTORY, AND HABITS

The adult is elongated, somewhat flattened, and about $\frac{1}{24}$ in. long, with a black body and light-coloured wings folded along the back (Fig. 58).

Eggs, which are laid in the plant tissues, hatch in about a week into pale, wingless nymphs. These pass through four stages or moults before they reach the adult stage. A generation is passed in three to five weeks.

CONTROL

Spray infested crops with DDT or nicotine sulphate plus white oil (see page 23). The former should not be applied after pods have formed.



Del. W. Cottier

Fig. 58.—Adult greenhouse thrips, *Heliothrips haemorrhoidalis*



Photo M. J. Dahlberg

Fig. 59. Bean leaves damaged by red spider-mite, *Tetranychus urticae*

MISCELLANEOUS

RED SPIDER-MITE (*Tetranychus urticae* Koch)

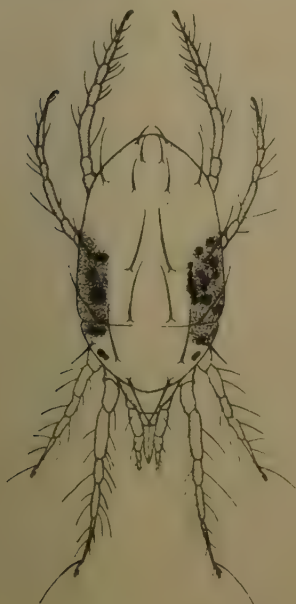
Red spider-mite, which occurs throughout the Dominion, frequently causes severe damage to bean crops grown under glass. Although this pest does not commonly occur on outdoor beans, there may be considerable damage when plants do become infested.

TYPE OF INJURY

Infested plants are reduced in vigour and the foliage becomes chlorotic. When infestation is severe, a white webbing may be observed on the lower surface of the leaves. During the initial stages of infestation, light-coloured spots appear on leaves where individual colonies of mites are feeding (Fig. 59). Later, these spots coalesce to form quite large areas.

HOST RANGE

In addition to beans, red spider-mite attacks strawberry, grape (under glass), cape gooseberry, peas, cucumber, tomato, violet, carnation, and many other plants.



Del. W. Cottier
Fig. 60.—The red spider-mite,
Tetranychus urticae



Del. W. Cottier
Fig. 61.—The red-legged earth-mite,
Halotydeus destructor

APPEARANCE, LIFE HISTORY, AND HABITS

The mite, (Fig. 60) passes the winter in the adult female form in crevices in wood or under leaves, rubbish, etc. This overwintering stage is red in colour. In the spring the spherical, smooth, shining, almost

colourless eggs are laid on leaves of the host plant. During the growing season the mites are yellow, yellowish green, brown, or red. They are approximately $\frac{1}{50}$ in. long. This mite spins a web on the undersides of leaves.

CONTROL

Spray infested bean crops with HETP or TEPP (see page 24). To be effective, sprays should be applied at high pressures in order to penetrate the webbing that is usually present on the undersides of leaves.

As many weeds act as alternative hosts of red spider-mite, clean cultivation assists in keeping down infestation.

RED-LEGGED EARTH MITE (*Halotydeus destructor* Tuck.)

Red-legged earth mite occurs only in a restricted area, viz., in the neighbourhood of Napier, Wairoa, and Gisborne. In these localities it sometimes causes considerable damage to dwarf, runner, and broad beans.

TYPE OF INJURY

Chlorotic spots that later become silvered develop on infested leaves. The dark, red-legged mites can be detected on damaged plants during the evening or at night.

HOST RANGE

In New Zealand the red-legged earth mite has also attacked tomato, peas, asparagus, silver beet, marrow, weeds such as Scotch thistle, wild turnip, and stagweed, and pasture plants such as subterranean clover, lucerne, and *Melilotus*.

APPEARANCE, LIFE HISTORY, AND HABITS

The mite (Fig. 61) is approximately $\frac{1}{25}$ in. long and has a dull, velvety, black body and red legs. It is very active and moves rapidly. The mite is active only during autumn, winter, and spring. During the summer only the egg stage is present. With the onset of cool, wet weather in the autumn, the eggs hatch, and in about sixty days the resulting mites are mature and laying eggs. Each mite lays fifty to one hundred eggs, which individually are barely visible but in the mass are easily recognized by their yellow or orange colour. The eggs are laid on the undersides of leaves. There are three generations a year. The largest number of mites occurs in the spring during September and October. They tend to be gregarious and cluster together when feeding. They are most active in the evening, early morning, and during dull weather. They appear to thrive best on light, sandy soils in areas that have a dry summer and a good winter rainfall.

CONTROL

Effective control can be obtained by spraying or dusting crops with DDT (see page 23) at intervals of ten to fourteen days. In infested

areas, treatment should commence as soon as plants appear above ground, and the ground around the plants should also be treated.

Infestation may be reduced by deep ploughing in early spring and late summer to bury the mites present.

As the mites feed and breed on many weeds, waste places such as headlands, fence lines, and ditches, should be kept clean.

SLATERS

Slaters, which are also known as woodlice, occur throughout New Zealand and sometimes cause damage to young bean plants.

TYPE OF INJURY

Although slaters normally feed on decaying vegetable matter, they do attack growing plants. They nibble pieces out of stems, leaves, and roots, thereby weakening the plants.

APPEARANCE, LIFE HISTORY, AND HABITS

Slaters are commonly found under pieces of wood or other rubbish lying about on the ground. They are grey, about $\frac{1}{2}$ in. long when fully grown, and oblong-oval (Fig. 62). They are segmented, convex on top and flat on the underside, and have seven pairs of legs. Eggs are produced in the spring, and these are carried on the underside of the body of the female until they hatch. Slaters are nocturnal and prefer moist situations.



Photo H. Powell

Fig. 62.—Slaters

CONTROL

A dust containing 5% active DDT sprinkled in places frequented by slaters controls them effectively. They can also be controlled with a poison bait of Paris green and dried blood (see Table 3, page 25).

To reduce infestation, decaying vegetable material, old sacks, and pieces of wood should not be left lying on the ground.

SLUGS AND SNAILS

Slugs and snails may attack bean plants just as they are coming through the ground and sometimes cause considerable damage.

An account of their habits and control is given on page 33 of this bulletin.

TABLE 4. COMPATIBILITY OF SPRAY MATERIALS USED ON BEANS AND BROAD BEANS

Explanation of Symbols

The positive (---) indicates that combinations are safe to use.

The negative (--) denotes incompatibility.

One asterisk (*) qualifies that mixtures should be prepared shortly before use, or that reactions may take place which affect efficacy and residual action, or that damage may occur under changeable climatic conditions.

Therapeutant	Bordeaux mixture	Colloidal sulphur	Colloidal sulphur	Copper oxychloride	Cuprous oxide	DDT emulsion	DDT paste	DDT wettable powder	Hydrated lime	Lime sulphur	Lime sulphur plus colloidal sulphur	Lindane emulsion	Nicotine sulphate	+++ TEPP	Thiam
Bordeaux mixture	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Colloidal sulphur	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Copper oxychloride	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Cuprous oxide	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
DDT emulsion	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
DDT paste	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
DDT wettable powder	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Hydrated lime	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Lime sulphur	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Lime sulphur plus colloidal sulphur	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Lindane emulsion	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Nicotine sulphate	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
TEPP	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Thiam	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Broad Beans

Although, in New Zealand, broad beans are grown to a much less extent than dwarf and runner beans, they are nevertheless planted in many market and domestic gardens throughout the Dominion. They have advantages over other types of bean in that they are hardy and can be grown during a period when few other green vegetables are available.

Broad beans are subject to several diseases and pests. Rust is the most serious disease, while black aphid is the most troublesome pest.

FUNGOUS DISEASES

BROAD-BEAN RUST

Rust disease of broad beans is caused by the fungus *Uromyces fabae* (Pers.) de Bary. It was first recorded in New Zealand by Kirk in 1905, and is widely distributed throughout the Dominion. In some seasons this disease causes severe losses in broad bean crops, particularly in the North Island.

SYMPTOMS

Rust usually appears first on plants after flowering, as small, whitish pustules or spots up to $\frac{1}{8}$ in. in diameter on leaves, leaf petioles, and stems. Frequently the spots are surrounded by light-yellow halos. The pustules soon burst and produce masses of cinnamon-brown spores which readily brush off leaves and stems (Fig. 63). When infection is severe, leaves are almost completely covered with the spore masses. In such instances partial defoliation and stunting of plants occurs, with resultant reduction in crop. Death due to rust infection is rare. Late in the



Photo S. A. Rumsey

Fig. 63. Broad-bean rust, showing infection on leaves

season the spore masses turn dark brown and form compact, cushion-shaped lesions which, when confluent on stems, may attain a length of 1 in. or more.

FACTORS FAVOURING INFECTION AND SPREAD

Rust is carried over from season to season as spores either on diseased bean refuse from previous crops or on infected volunteer plants. During the growing season spores from infected plants are readily carried long distances by wind to other plants. Temperatures between 60° F and 70° F are most favourable for germination of spores and development of the disease. After initial infection, rapid spread of rust is favoured by moderate temperatures and high humidities.

CONTROL.

Remove and burn all diseased material after crop is harvested.

The disease is difficult to control once established, but its severity can be reduced by spraying plants every fourteen to twenty-one days with lime sulphur 1-150 plus colloidal sulphur 2 lb. and Agral L. 4 oz. to 100 gal. water (see page 23). It is essential that applications be made before the disease becomes severe. In districts where rust is prevalent every year, spraying should commence when plants are approaching the flowering stage.

CHOCOLATE SPOT

The disease known as chocolate spot is caused by strains of the fungus *Botrytis cinerea* Pers. (see grey mould, page 39), which is common on a wide variety of host plants. It was first recorded on broad beans in New Zealand in 1939. This disease is sometimes troublesome on crops subjected to severe climatic conditions during the winter months. It is more common on winter-sown beans than on those sown in the spring.

SYMPTOMS

The disease appears first as small, dark-brown, chocolate-coloured spots or blotches of variable shape on leaves (Fig. 64), leaf stalks, and stems. On leaves, these spots occur on both surfaces and may either be superficial or extend right through the leaf tissues. On leaf stalks and stems, lesions usually occur in the form of brown streaks, sometimes with a reddish margin. The disease is checked by dry weather, lesions remaining as spots or streaks, but during periods of prolonged rainfall and high humidity it may occur in a more aggressive form. In such cases the spots coalesce, partial defoliation occurs, and some plants may be killed.

FACTORS FAVOURING INFECTION AND SPREAD

The disease is carried over from one season to the next on infected plant debris of many kinds, including broad beans. On such material it is frequently found at all periods of the year, and spores are readily carried to growing plants by winds. Temperatures of 60° F to 70° F are most favourable for development of the disease, while free water on



Photo S. A. Rumsey

Fig. 64.—Chocolate spot, showing infection on broad-bean leaves

the plants is necessary for infection. The aggressive form of the disease occurs only during prolonged periods of high humidity. In soils deficient in potash, plants are subject to the disease, particularly if crop is dense and drainage inadequate.

CONTROL

All bean refuse from previous crops should be collected and burnt and crops should be rotated. In areas where the disease is troublesome, plants should be sprayed every two to three weeks during the winter months with thiram (see page 23).

Plants should be well spaced in rows and adequate drainage maintained, particularly in heavy soils.

SCLEROTINIA DISEASE (*Sclerotinia sclerotiorum*)

This disease is described fully under bean diseases (see page 37). It is occasionally found on broad beans, but is of minor importance.

LEAF SPOT OF BROAD BEANS (*Ascochyta fabae* Speg.)

This fungus is of little economic importance, but is sometimes found on broad beans. It infects leaves mainly, but is occasionally found on

stems and pods. The fungus produces circular, light-brown spots up to $\frac{3}{8}$ in. in diameter, with pallid grey centres and dark-brown margins. Minute brown fruiting bodies containing spores of the fungus are formed in central areas of spots.

For control, spray plants either with bordeaux mixture or copper oxychloride (see page 22).

VIRUS DISEASES

PEA MOSAIC

As with peas, pea mosaic causes greater losses on broad beans in some localities than others. Incidence is probably greatest in Wanganui, Manawatu, Marlborough, and north Canterbury, but may sometimes be high in other districts also. Incidence, particularly in domestic gardens, often reaches 100%. Since the disease causes stunting of plants and reduces the number and size of pods, yields are greatly reduced.

SYMPTOMS

The first symptom is vein clearing of young leaves, this being replaced later by a more general mosaic pattern (Fig. 65). Infected plants are stunted and the foliage is paler than normal. Pods do not set freely and remain small.

The host range and the method of spread and overwintering have already been given on page 27.

Varietal resistance in broad bean has not been demonstrated.

Control measures are the same as given on page 29 for pea mosaic on garden peas in market and domestic gardens.



Fig. 65.—Pea-mosaic on broad bean, showing mosaic mottling; healthy leaf on right

Photo H. Drake

PESTS

BEAN APHID (*Aphis craccivora* Koch.)

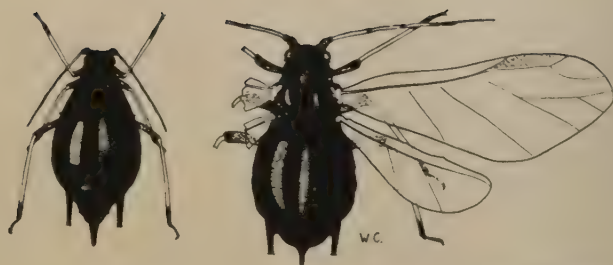
This pest is common on broad beans, particularly in the South Island and the lower half of the North Island. The young shoots may be severely infested (Fig. 66), with consequent restriction in growth of plants. Bean aphid may also be found on other types of beans, but generally to a much lesser extent.

Hosts are beans, peas, tares, vetches, clovers, and other plants.



Photo D. Read, Cawthron Institute

Fig. 66.—Broad-bean head infested with black bean-aphid, *Aphis craccivora*



Del. W. Cottier

Fig. 67.—Adult black bean-aphids, *Aphis craccivora*

APPEARANCE, LIFE HISTORY, AND HABITS

Adults are of two kinds, namely, wingless and winged forms (Fig. 67). The wingless female is shining black and approximately $\frac{1}{2}$ in. in length. The winged form is about the same length and has two large forewings and two much smaller hind wings. Immature stages have a sooty appearance. Adult females produce living young, with the result that infestation builds up rapidly.

CONTROL

Spray with nicotine sulphate plus soft soap (see page 24).

Plant Therapeutants

Most fungicides and insecticides used in plant protection are applied for the purpose of preventing establishment of diseases and pests. In some instances, e.g., soil disinfection, treatments are eradicant. In general, it is advisable to use a regular system of applying plant therapeutants, as the grower has no way of knowing beforehand what diseases or pests may occur, or the severity of their attack.

Plant therapeutants may be used for eradication of organisms in the soil, for protection of seed (in storage and after sowing), and for application to growing plants as sprays or dusts. These methods are described below.

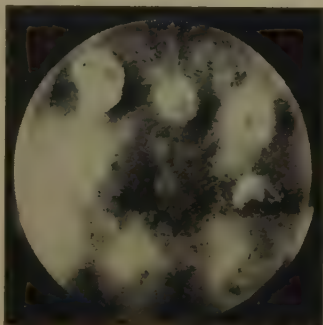


Photo H. Tooley

Fig. 68.—*Pythium* infection of pea seeds lifted from soil two days after sowing

SEED PROTECTION

Failure of seeds to germinate or of seedlings to emerge is known as pre-emergence damping off, while death of seedlings after emergence is known as post-emergence damping off.



Photo H. Tooley

Fig. 69.—Organisms growing from germinating pea and bean seed

Both types of damping off are caused by:

- (1) Soil-borne fungi (Fig. 68), bacteria, or insects, which cause rotting of seeds or death of seedlings.
- (2) Seed-borne fungi or bacteria, which cause rotting of seeds in storage or after planting (Fig. 69).
- (3) Seed-borne fungi and bacteria, which cause failure of seeds to germinate or death of seedlings.

Seed treatment is especially important in control of damping off. Treatment protects the seed and young seedlings from attack and improves the stand, yield, and quality of plants (Fig. 70). Although not highly effective for control of seed-borne diseases such as collar rot of peas, treatment reduces the incidence of such diseases.

The treatments recommended (Table 1, page 13) give satisfactory control of harmful organisms without causing reduction of germination or damage to seedlings.

Soil conditions have an important effect on the susceptibility of seeds and seedlings to disease. With high temperatures and moderate soil moisture, which encourage rapid germination and strong seedling growth, use of untreated seed is often satisfactory. When cool and wet soil conditions delay germination of seed and emergence of seedlings, thus prolonging the period during which pathogenic organisms can attack them, seed treatment is essential. Under unfavourable conditions the strong, healthy plants produced from treated seed are usually less subject to disease attack than less vigorous plants grown from untreated seed.



Photo J. Endt

Fig. 70.—Emergence of dusted pea seed in *Pythium*-infected soil. Front pots sown with untreated seed



Photo S. A. Rumsey

Fig. 71.—Continuous-action seed-dressing machine allowing treatment of 40 lb. seed

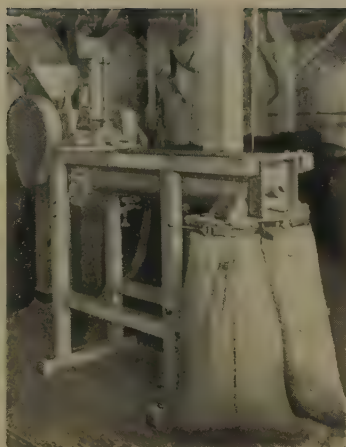


Photo S. A. Rumsey

Fig. 72.—Machine for large-scale application of seed treatment

Seed can be protected by the application of seed dusts, which are inexpensive and easy to apply. They contain active ingredients (fungicides or insecticides), fillers (china clay, talc, etc.) which ensure even distribution of the active ingredients, and sticking agents which ensure adhesion of dusts to seed.

Quantities of dust applied are measured in relation to weight of seed and are defined as percentages of seed weight.

For treatment of seeds purchased in small packages, and when the quantity of dust required is difficult to measure, a very small amount of dust, sufficient to cover the tip of small penknife blade, is added to the packet, which should be shaken until the seeds and dust are well mixed.

A more satisfactory way of applying a seed dust to small quantities of seed is to weigh the seed and the required quantity of disinfectant before placing both in a flask or a jar with a closely fitting lid. Seeds and dust should be shaken for five minutes to ensure adequate coverage.

For treatment of large quantities of seed, rotary machines are used. The mixing drum revolves at approximately forty revolutions per minute, and adequate coverage is obtained after five minutes' rotation (Figs. 71 and 72).

Small-scale application of dusts is not risky. Large-scale application, however, may involve operators in some toxicity hazards, and the following precautions are recommended to avoid injury:

Wear a clean dry cloth or a dry filter mask over the nose and mouth (Fig. 73). Dust-mask filters should be changed regularly, according to manufacturers' directions.

Avoid accumulation of dust on the skin.

Use protective ointment over exposed parts of the skin if sensitive to irritation.



Photo J. Endt

Fig. 73.—Operator wearing dust mask during seed treatment

Use gloves if handling large amounts of dust.

Thoroughly wash hands, face, and exposed parts of the body before eating or smoking.

At the end of operations clean up spilt material and do not allow dust to accumulate on equipment or on the floor.

Label treated seeds distinctly.

Do not use treated seeds for food or for feeding to stock.

SOIL DISINFECTION

For control of soil-borne diseases and pests it is necessary that infection or infestation be eradicated from the soil before the crop is planted. The principal methods used for disinfecting soils are by steam heating and by chemicals. The only soil-borne diseases of consequence attacking pea and bean crops are those causing damping off, foot rots, and pea wilt. Damping off can be effectively prevented by seed treatment, the others by soil disinfection. Soil treatments, however, are too costly to be contemplated for other than glasshouse crops, and are therefore not described in this bulletin. Those interested in the details of soil disinfection are referred to "Tomato Diseases and Pests in New Zealand and Their Control", *N.Z. Dep. sci. industr. Res. Inf. Ser. 2*.

SPRAYING AND DUSTING

The simplest apparatus for applying fungicides and insecticides are hand-operated sprayers. Although suitable for small areas, it is unwise to rely upon them for the protection of large areas, since in attempting to spray the crop in a reasonable time spray coverage may be inadequate. Several types of traction or power-operated sprayers are on the market. These machines give the best distribution of plant therapeutants and are economical in operation. Satisfactory sprayers should operate a six-row

boom with three nozzles per row and should deliver the spray at a pressure of 300 lb. per square in. The volume of spray applied per acre will vary with the speed of operation, but should not be less than 50 gallons.

Dust treatments are not as effective in control of fungous diseases as are sprays. They can, however, be used effectively in control of insect pests, especially in still weather. Where hand equipment is used, dust guns should be adjusted to deliver the required amount for satisfactory coverage. Better coverage of the lower surfaces of leaves is obtained by directing the blower towards the soil. A thin and even distribution should be aimed at, as spotty or heavy deposits may cause plant damage.

Successful control of diseases and pests depends on—

Correct diagnosis of disease or pest to be controlled.

Choice of high quality material.

Determination of correct concentration.

Efficiency of application.

Application of therapeutant before establishment of diseases and pests.

Spraying or dusting at intervals to ensure adequate coverage under all weather conditions.

As a guide to growers, a list of certified fungicides and insecticides is given in this bulletin (see page 80). These lists are published every six months and are obtainable from the Plant Diseases Division, Auckland.

A brief description of fungicides and insecticides and their use for protection of pea and bean crops is given in Tables 1, 2, and 3 (see pages 13, 22, and 25).

It is often an advantage to combine fungicides and insecticides in a spray mixture to reduce the cost of application. Materials given in Table 2 are listed in a compatibility chart (Table 4, page 68) which shows the materials that can or cannot be mixed for application to beans and broad beans.

*Certification of Therapeutants**

By G. H. CUNNINGHAM, Director, Plant Diseases Division, Department of Scientific and Industrial Research, Auckland

Our work of improvement in methods of combating bacterial, fungous, and insect diseases and pests of plants has shown the necessity for assessing the value of the many sprays, dusts, fumigants, etc.—collectively termed therapeutants—placed on the New Zealand market. Tests carried out during the past years have demonstrated that, of these, quite half were ineffectual for the purpose for which they were sold. It is apparent, therefore, that orchardists, nurserymen, and farmers should be provided with some simple means whereby they are enabled to procure only efficient materials.

To this end the Plant Diseases Division has introduced the Certification of Therapeutants, operated on the following lines:

†(1) The manufacturer of the therapeutant (or his agent) offers to the Division for certification samples of those products he wishes to place upon the New Zealand market. Accompanying his application are particulars regarding its composition, methods of analysis (where necessary), and evidence showing it is worthy of test. Such information is treated as confidential by the Division.

(2) Products are then tested in the laboratory and field under rigorously controlled conditions. Tests are mainly biological, although chemical and/or physical analyses are made to check the composition of different samples of the same product. In addition are ascertained the most efficient concentrations at which the product is safe to apply to plants and yet will give most effectual control of diseases or pests.

(3) If the therapeutant passes the tests imposed, it is certified and the manufacturer (or his agent) supplied with a *Warrant of Certification*. This is to be incorporated in or on the label of the product, since it bears the registered trade mark and also for the purposes for and concentrations at which it may be used. The product is also listed in the *Certification Lists* published in July and January of each year and distributed to all users of therapeutants on a commercial scale. Orchardists, nurserymen, and farmers may therefore purchase any certified product with confidence, knowing that it is efficient for the purpose for which it is offered for sale in the Dominion.

Plant Diseases Division

S.I.R. 14

*Supplement to *The Orchardist of New Zealand*, February 1954.

†Detailed particulars are supplied in the Plant Diseases Division Form No. 1—Certification of Therapeutants—which may be procured from the Director, Plant Diseases Division, Private Bag, Auckland.

Form No. 6

CERTIFICATION OF THERAPEUTANTS

Thirty-fourth List, January 1954

The publication of this cancels all previous lists

*Products are arranged alphabetically, consequently the sequence in which they are presented does not imply any order of merit.
 †Concentrations vary according to the disease to be controlled and the susceptibility of the host plant to spray damage. Reference should be made to the local Orchard or Agricultural Instructor of the Department of Agriculture for additional information in the use of these materials.
 ‡Extreme caution is advisable when preparing and using preparations containing materials dangerous to the operator.

*Trade Name of Product	Manufacturer or Agent	Purpose	†Remarks
ACID LEAD ARSENATES			
Blue Bell	N.Z. Fruitgrowers' Federation Ltd., Wellington, New Zealand, agents	Control of chewing insects, such as leaf-roller caterpillar, codling moth, vegetable weevil, tomato grubbs, grass grub larvae, raspberry-bud moth, etc.	Apply at rates of 1 lb. per 100 gallons on stone fruits, 1½ to 2 lb. per 100 gallons on apples and pears, and 2½ to 3 lb. per 100 gallons on tomatoes.
Cooper's Arsinette	Imperial Chemical Industries (N.Z.) Ltd., Wellington, New Zealand, agents		
Fertona	Ivon Watkins Ltd., New Plymouth, New Zealand		
Hemway	Ivory Spray Chemicals Ltd., Nelson, New Zealand		
Lunevale	Ivory Spray Chemicals Ltd., Nelson, New Zealand		
Orehard Brand	Ivory Spray Chemicals Ltd., Nelson, New Zealand		
Talbot	Gollin and Co. Ltd., Auckland		
AZO BENZENE AEROSOLS			
Aerocide A.B. 30	Freshfields Ltd., Wellington, New Zealand	Control of red spider-mite in grape-houses	Apply one shot (40 ml.) by Aerocide dispersing method to 5,000 cubic feet of glasshouse space at temperatures exceeding 70° F. Dosages may have to be increased in leaky glasshouses.

CERTIFICATION OF THERAPEUTANTS—continued

*Trade Name of Product	Manufacturer or Agent	Purpose	†Remarks
AZO BENZENE SMOKES			
Azobenzene Smoke Generators	Imperial Chemical Industries (N.Z.) Ltd., Wellington, New Zealand	Control of red spider-mite in grape-houses	Apply one generator to each 3,000 cubic feet of glasshouse space. Rate of application to be increased where houses allow excessive escape of smoke. Two to three applications at ten-day intervals and temperatures during treatment should not be less than 70° F.
Murfume Azobenzene Smokes	Ivory Spray Chemicals Ltd., Nelson, New Zealand		As for above, but use one canister size 6 to each 4,000 cubic feet., midget size, to each 1,200 cubic feet, and size 0 to each 500 cubic feet of glasshouse space.
BHC (Mixed Isoners) WETTABLE POWDERS			
Agrocide	Imperial Chemical Industries (N.Z.) Ltd., Wellington, New Zealand	Control of woolly aphis on pip fruit and wire worm in soil	6·5% g.i. Apply at 4 to 5 lb. per 100 gallons at dormant.
Dipac	Freshfields Ltd., Wellington, New Zealand		
COLLOIDAL SULPHURS			
Colsul 25	The Fruitgrowers' Chemical Co., Mapua, Nelson, New Zealand	Control of blackspot and powdery mildews	Apply at concentrations of 3 lb. per 100 gallons when combined with lime sulphur or 5 lb. when used alone.
Colsul 40	The Fruitgrowers' Chemical Co., Mapua, Nelson, New Zealand		Apply at concentrations of 2 lb. per 100 gallons when combined with lime sulphur or 3 lb. when used alone.
Sulphaloid	Ivon Watkins Ltd., New Plymouth, New Zealand		

COPPER OXYCHLORIDE WETTABLE POWDERS

Cop-ox Coxyzan Cuprox	F. M. Winstone (Seeds) Ltd., Auckland, New Zealand Gollin and Co. Ltd., Auckland, New Zealand Imperial Chemical Industries (N.Z.) Ltd., Wellington, New Zealand Ivon Watkins Ltd., New Plymouth, New Zealand Ellico Ltd., Onehunga, Auckland	Control of late blight of tomatoes and potatoes, septoria spot of celery, ring spot of lettuce, and halo blight of beans	Apply at concentrations of 5 lb. per 100 gallons.
Funguran Oxti-cop			

COPPER SULPHATE

Te Papapa	The New Zealand Farmers' Fertilizer Co., Auckland, New Zealand	Preparation of bordeaux mixture	Purity of 98% to 99%.
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CUPROUS OXIDE WETTABLE POWDERS

Cupromox Perenox	Ivory Spray Chemicals Ltd., Nelson, New Zealand Imperial Chemical Industries (N.Z.) Ltd., Wellington, New Zealand	Control of late blight of tomatoes	Apply at concentrations of 3 lb. to 5 lb. per 100 gallons.
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DDD DUSTS

Micronised D2 Dust (Rothane)	The Fruitgrowers' Chemical Co., Mapua, Nelson, New Zealand	Control of susceptible species of chewing and sucking insects, such as white butterfly and diamond-back moth	2% technical D.D.D. Apply at 10 to 25 lb. per acre according to size of plants.
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DDD WETTABLE POWDERS

DDD-25	The Fruitgrowers' Chemical Co., Mapua, Nelson, New Zealand	Control of susceptible species of chewing and sucking insects, such as apple leaf- roller and other pests listed under D.D.T. (W.P.)	25% technical D.D.D. Apply at concentrations of 1 to 2 lb. per 100 gallons.
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CERTIFICATION OF THERAPEUTANTS—continued

*Trade Name of Product	Manufacturer or Agent	Purpose	†Remarks
DDT AEROSOLS			
Aerocide DDT	Freshfields Ltd., Wellington, New Zealand	Control of tomato white fly in glasshouses	Apply 1 shot (40 ml.) by Aerocide dispersing method to 5,000 cubic feet of glasshouse space at temperatures exceeding 70° F. Dosages may have to be increased in leaky glasshouses.
DDT DUSTS			
D-Dust No. 1	The Fruitgrowers' Chemical Co., Mapua, Nelson, New Zealand	Control of susceptible species of chewing and sucking insects, such as white butterfly and diamond-back moth	1·0% p.p.i.
D-Dust No. 2	The Fruitgrowers' Chemical Co., Mapua, Nelson, New Zealand		2·0% p.p.i.
Puff	P. and W. Henderson Ltd., Christchurch, New Zealand		2·0% p.p.i. Apply at 10 to 25 lb. per acre according to size of plants.
Grubnox	The Fruitgrowers' Chemical Co., Mapua, Nelson, New Zealand	Control of grass grub, and subterranean caterpillar	50% p.p.i. Apply in late autumn or early spring. (1) to pastures at 2 to 4 lb. per acre; (2) to lawns at 1½ lb. per 1,000 square yards.
DDT and BHC (Mixed Isomers) COMBINATIONS. DUSTS			
Pespruf 2G	Imperial Chemical Industries (N.Z.) Ltd., Wellington, New Zealand	Control of susceptible species of chewing and sucking insects, such as white butterfly, diamond-back moth, and cabbage aphid	1% p.p.i. D.D.T. plus 0·1% BHC. Apply at 10-25 lb. per acre according to size of plants.

DDT EMULSIONS

Trimort Wettable DDT	Trimol Laboratories, Auckland, New Zealand	Control of susceptible species of chewing and sucking insects as listed in D.D.T. (W.P.)	20% p.p.i. Apply at $\frac{1}{2}$ to 2 pints in 100 gallons. For onion thrips use 4 pints in 100 gallons.
DD Temul	S. W. Peterson and Co. Ltd., Wellington, New Zealand		

DDT PASTES

Atapest	S. W. Peterson and Co. Ltd., Wellington, New Zealand	Control of susceptible species of chewing and sucking insects as listed in D.D.T. (W.P.)	33 $\frac{1}{3}$ % p.p.i. Apply at $\frac{1}{3}$ to 3 lb. per 100 gallons.
DeDeTane	Ivory Spray Chemicals Ltd., Nelson, New Zealand		40% p.p.i. Apply at $\frac{1}{3}$ to 2 $\frac{1}{2}$ lb. per 100 gallons.

DDT WETTABLE POWDERS

D-Spray 50	The Fruitgrowers' Chemical Co., Mapua, Nelson, New Zealand	Control of susceptible species of chewing and sucking insects, such as citrus leaf-roller, dicky, rice-weevil, bronze beetle, brown beetle, grape mealy-bug, codling moth, apple leaf-hopper, tomato grub, tomato white-fly, green vegetable-bug, white butterfly, diamond-back moth, vegetable weevil, grass grub, etc.	50% p.p.i. Apply at concentration of $\frac{1}{2}$ to 2 lb. per 100 gallons.
Pespruf 50	Imperial Chemical Industries (N.Z.) Ltd., Wellington, New Zealand		

FERBAM WETTABLE POWDERS

Fernspray	The Fruitgrowers' Chemical Co., Mapua, Nelson, New Zealand	Control of blackspot of apples in application after closed calyx	70%. Apply at concentrations of 2 lb. per 100 gallons.
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CERTIFICATION OF THERAPEUTANTS—continued

*Trade Name of Product	Manufacturer or Agent	Purpose	†Remarks
GAMMA BHC (Lindane) DUST			
Nexa Dust 20	Ivon Watkins Ltd., New Plymouth, New Zealand	Control of susceptible species of chewing and sucking insects, such as white butterfly and diamond-back moth	1%. Apply at 10-25 lb. per acre according to size of plants.
Nexa Dust	Ivon Watkins Ltd., New Plymouth, New Zealand	Control of grass grub and subterranean caterpillar	20%. Apply in late autumn or early spring. (1) To pastures at 5-10 lb. per acre, (2) to lawns at 3½ lb. per 1,000 square yards.
GAMMA BHC (Lindane) SMOKES			
Celanex Strips	Ivon Watkins Ltd., New Plymouth, New Zealand	Control of white fly in glass-houses	Apply 1 strip (1.9 in. x 12 in.) to 850 cubic feet of glasshouse space, at temperatures exceeding 70° F. Dosages may have to be increased in leaky glasshouses.
GAMMA BHC (Lindane) WETTABLE POWDERS			
Isotox	Ivory Spray Chemicals Ltd., Nelson, New Zealand	Control of woolly aphis on pip fruit, cabbage aphid and wireworm in soil (by seed dressing)	16%. Apply at 1½ lb. per 100 gallons.
Lindane 25	The Fruitgrowers' Chemical Co., Mapua, Nelson, New Zealand		25%. Apply at 1 lb. per 100 gallons.
Nexa	Ivon Watkins Ltd., New Plymouth, New Zealand		16%. Apply at 1½ lb. per 100 gallons.

H.E.T.P.†

Hexone	Imperial Chemical Industries (N.Z.) Ltd., Wellington, New Zealand	Control of susceptible species of sucking insects, such as red mite, red spider, aphids, green vegetable-bug, thrips, etc.	Not less than 15% TEPP. Apply at $\frac{1}{4}$ to 1 pint per 100 gallons.
HYDRATED LIME			
Dyserth	Australia and New Zealand Bank Ltd., Auckland, New Zealand	Preparation of horticultural sprays	Not less than 95% calcium hydroxide.
Hindlym Limbux	Rosser Bros. Ltd., Auckland, New Zealand Imperial Chemical Industries (N.Z.) Ltd., Wellington, New Zealand		
LIME SULPHUR			
Lawrys Te Papapa	W. L. Lawry, Stoke, Nelson, New Zealand The New Zealand Farmers' Fertilizer Co., Auckland, New Zealand	Control of fungous diseases, such as apple mildew and black spot, and sucking insects, such as scales	Polysulphide content of 15%.
NICOTINE SULPHATES‡			
Black Leaf 40	F. Cooper Ltd., Wellington, New Zealand, agents	Control of sucking insects, such as aphids	Apply at rate of 1 pint in 75 or 100 gallons.
Black Spot	Frank M. Winstone (Seeds) Ltd., Auckland, New Zealand		Apply one shot (40 ml.) by Aerocide dispersing method to 8,000 cubic feet of glasshouse space at temperatures exceeding 70° F. Dosage may have to be increased in leaky glasshouses. A respirator should be worn.
Britnico	Imperial Chemical Industries (N.Z.) Ltd., Wellington, New Zealand		
P.B.I. 40 Nicoforty	Freshfields Ltd., Wellington, New Zealand N.Z. Fruitgrowers' Federation Ltd., Wellington, New Zealand		
Nicotox 40 P.B.I. Aerocide	M. T. Vanderpump, Hastings, New Zealand Freshfields Ltd., Wellington, New Zealand		

CERTIFICATION OF THERAPEUTANTS—*continued*

*Trade Name of Product	Manufacturer or Agent	Purpose	†Remarks
PARATHION EMULSIONS			
Folidol	Ivon Watkins Ltd., New Plymouth, New Zealand	Control of susceptible species of sucking insects, such as red spider-mite, aphids, green vegetable-bug	31·5% w/w. Apply at 5–15 fluid ounces per 100 gallons.
Fosferno 20	Imperial Chemical Industries (N.Z.) Ltd., Wellington, New Zealand		20% w/w. Apply at 7–20 fluid ounces per 100 gallons.
PHENYL MERCURY SALICYLATE AEROSOLS			
Aerocide P.M.4	Freshfields Ltd., Wellington, New Zealand	Control of leaf mould of tomatoes	Apply one shot (40 ml.) by Aerocide dispersing method to 5,000 cubic feet of glasshouse space at temperatures exceeding 70° F. Dosage may have to be increased in leaky glasshouses.
PYRETHRUM. AEROSOLS			
Piremyst L.	St. James' Tobacco Co. Ltd., Auckland, New Zealand	Control of tobacco moth	Apply at 15 ml. (by compressed air) to 1,000 cubic feet of warehouse space. Dosages may have to be increased in leaking warehouses.
SALICYLANILIDE. PASTES			
Shirlan A.G.	Imperial Chemical Industries (N.Z.) Ltd., Wellington, New Zealand	Control of leaf mould of glasshouse tomatoes	Apply at concentrations of 3 lb. per 100 gallons.

SCHRADAN

Pestox 3	Canterbury (N.Z.) Seed Co. Ltd., Christchurch	Control of susceptible species of sucking insects, such as red spider-mite and aphids	55% w/v Schradan and 11% w/v related compounds. Apply at 15-25 fluid ounces per 100 gallons. Use only on ornamental plants.
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SEED DISINFECTANTS

Agrosan G.N.	Imperial Chemical Industries (N.Z.) Ltd., Wellington, New Zealand	Control of cereal smuts and stripe disease	Apply as seed dressing at rate of 2 oz. per bushel.
Ceresan	Fassett and Johnson Ltd., Wellington, New Zealand		
Fernasan	Imperial Chemical Industries (N.Z.) Ltd., Wellington, New Zealand	Control of pre-emergence damping-off of peas, lettuce, and French beans	Apply as seed dressing at rate of 2 oz. per bushel.
Phygon XL	The Fruitgrowers' Chemical Co., Mapua, Nelson, New Zealand		
Spergon	Turner Cough Ltd., Northcote, Auckland, New Zealand		
Tetram	Ivory Spray Chemicals Ltd., Nelson, New Zealand		
Tetroc	Hardie Trading Co. (N.Z.) Ltd., Auckland, New Zealand, agents		
Thiro-Dust	The Fruitgrowers' Chemical Co., Mapua, Nelson, New Zealand		

SOIL FUMIGANTS AND DISINFECTANTS†

Larvacide	N.Z. Fruitgrowers' Federation Ltd., New Zealand, agents	Control of root-knot nematode, wilt diseases and grass-grub larvae in lawns	Apply at 3-4 ml. per square foot in moderately moist soil and temperatures over 65° F.
Shell D-D	Shell Company of New Zealand Ltd., Wellington, New Zealand	Control of root-knot nematode, wilt diseases and grass-grub larvae in lawns	Apply at 3-4 ml. per square foot in moderately moist soil and temperatures over 65° F.

CERTIFICATION OF THERAPEUTANTS—continued

*Trade Name of Product	Manufacturer or Agent	Purpose	†Remarks
SPRAYING OILS			
	Summer ("White") Oils		
Avon Emulsifine 30 Gargyle White	Sims, Jones Ltd., Christchurch, New Zealand Vacuum Oil Company Prop. Ltd., Wellington, New Zealand	Control of sucking insects, such as scales, red spider, and red mite	Apply at concentrations of 1% on apples and 3% on citrus. Concentrations to be based on oil content.
Shell White Spray	Shell Company of New Zealand Ltd., Wellington, New Zealand		
Volck 96 Medium	Ivory Spray Chemicals Ltd., Nelson, New Zealand		
	Winter ("Red") Oils		
Avon Emulsifine Gargyle Red	Sims, Jones Ltd., Christchurch, New Zealand Vacuum Oil Company Prop. Ltd., Wellington, New Zealand	Control of sucking insects, such as scales, red spider, and red mite in dormant season	Apply at concentrations of 4% to 5%. Concentrations to be based on oil content.
Gargyle Winter Spray Emulsion Shell Palespray	Vacuum Oil Company Prop. Ltd., Wellington, New Zealand Shell Company of New Zealand Ltd., Wellington, New Zealand		
Shell Red Spray	Shell Company of New Zealand Ltd., Wellington, New Zealand		
Winter Volck	Ivory Spray Chemicals Ltd., Nelson, New Zealand		
TEPP†			
Murphy Tepp	Ivory Spray Chemicals Ltd., Nelson, New Zealand	Control of susceptible species of sucking insects such as red spider-mite, aphids, green vegetable-bug	Not less than 38% TEPP. Apply at $\frac{1}{8}$ to $\frac{1}{2}$ pint per 100 gallons.

THIRAM WETTABLE POWDERS

Thirospray	--	The Fruitgrowers' Chemical Co., Mapua, Nelson, New Zealand	Control of black spot of apples in applications after closed calyx	50% Thiram. Apply at concentrations of 2 lb. per 100 gallons.
ZIRAM WETTABLE POWDERS				
Zirospray	--	The Fruitgrowers' Chemical Co., Mapua, Nelson, New Zealand	Control of ripe spot of apples	70% Ziram. Apply at concentrations of 2 lb. in 100 gallons in January and in February.

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